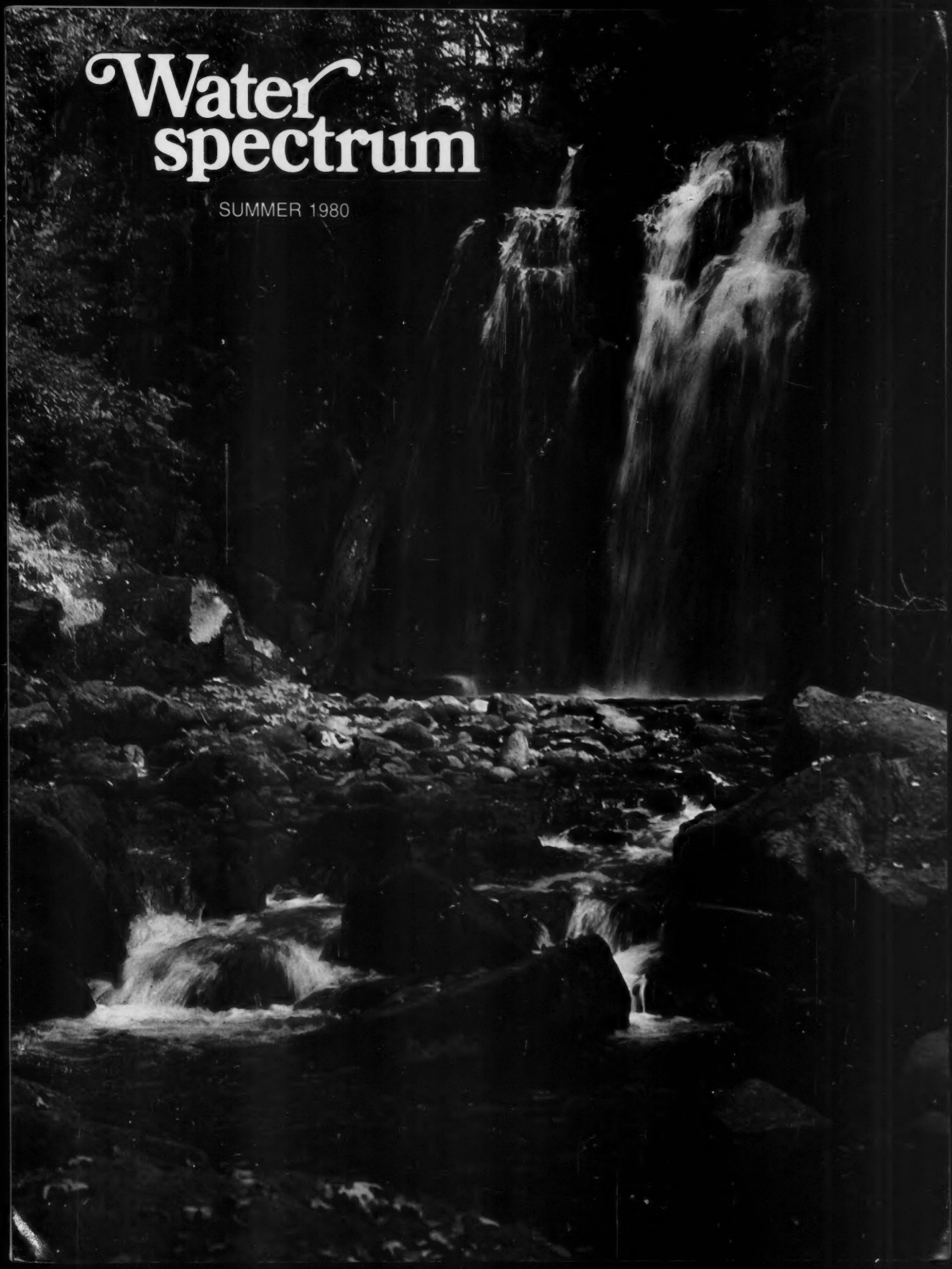
Water spectrum

SUMMER 1980



Water spectrum

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Editor, Water Spectrum
U.S. Army Corps of Engineers
Water Resources Support Center (WRSC)
Fort Belvoir, VA 22060
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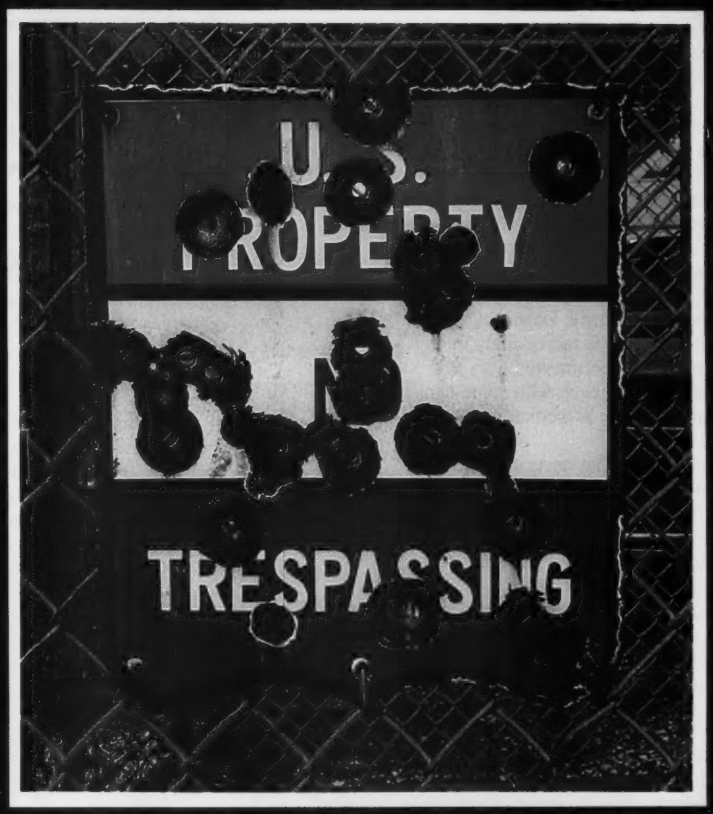
COVER: *"From the waterfall he named her Minnehaha, Laughing Water."—Longfellow*
(Photo by Bruce Berg)

WATER RESOURCES PLANNING:



CONFLICT MANAGEMENT

by William B. Lord

Conflict is inevitable whenever groups form to reach decisions. Perfect agreement is both unusual and undesirable, because its absence characterizes a static society, bereft of new ideas and innovative capacity. Nonetheless, conflict can get out of hand and become unproductive. It must be managed if we are to enjoy its benefits but avoid unnecessary costs.

Federal water resources development has never been free of conflict. In recent years, however, this conflict seems to have become more intense and more pervasive. Also, there is little reason to believe that we are managing it well. The water resources planning process, within and around which much conflict occurs, has become longer, more costly, and more contentious. Its outcome is increasingly in doubt. Water resources agencies have experimented with new and more open planning methods, and even with some explicit conflict resolution techniques, such as mediation. No magic answers have appeared.

This article, which grew out of an unsuccessful attempt to apply conflict resolution techniques within a real water resource planning conflict, focuses on the institutional aspects of water resources decision making. The term "institutions" is used broadly, to mean any socially accepted ways of doing things. It includes laws, customs and patterns of political behavior. It does not mean organizations, in this sense. The aim of this article is to see whether there may be institutional obstacles to effective conflict management within the planning process; obstacles which may account for the seeming lack of general progress in resolving water conflicts. The ultimate conclusion is that there are structural aspects of existing institutions, both within the planning process itself and in the political structure within which planning is conducted, which militate against effective conflict management. No stones are cast. No agency, political body, or interest group is at fault. Instead, it seems that the decision-making structure which has evolved over many years is simply inappropriate to the problems it now faces. Dealing with this situation may be far more difficult and frustrating than finding a convenient devil to exorcise or finding a technical "quick fix," in the form of a new planning or conflict resolution technique.

Dr. Lord is president of Policy Sciences Associates of Boulder, Colorado. He is a former staff economist in the Office of the Secretary of the Army. This article is adapted from a paper which appeared in the October 1979 issue of the *Water Resources Bulletin* and is based upon research funded by the Office of Water Research and Technology.

Federal water resources development has never been free of conflict.

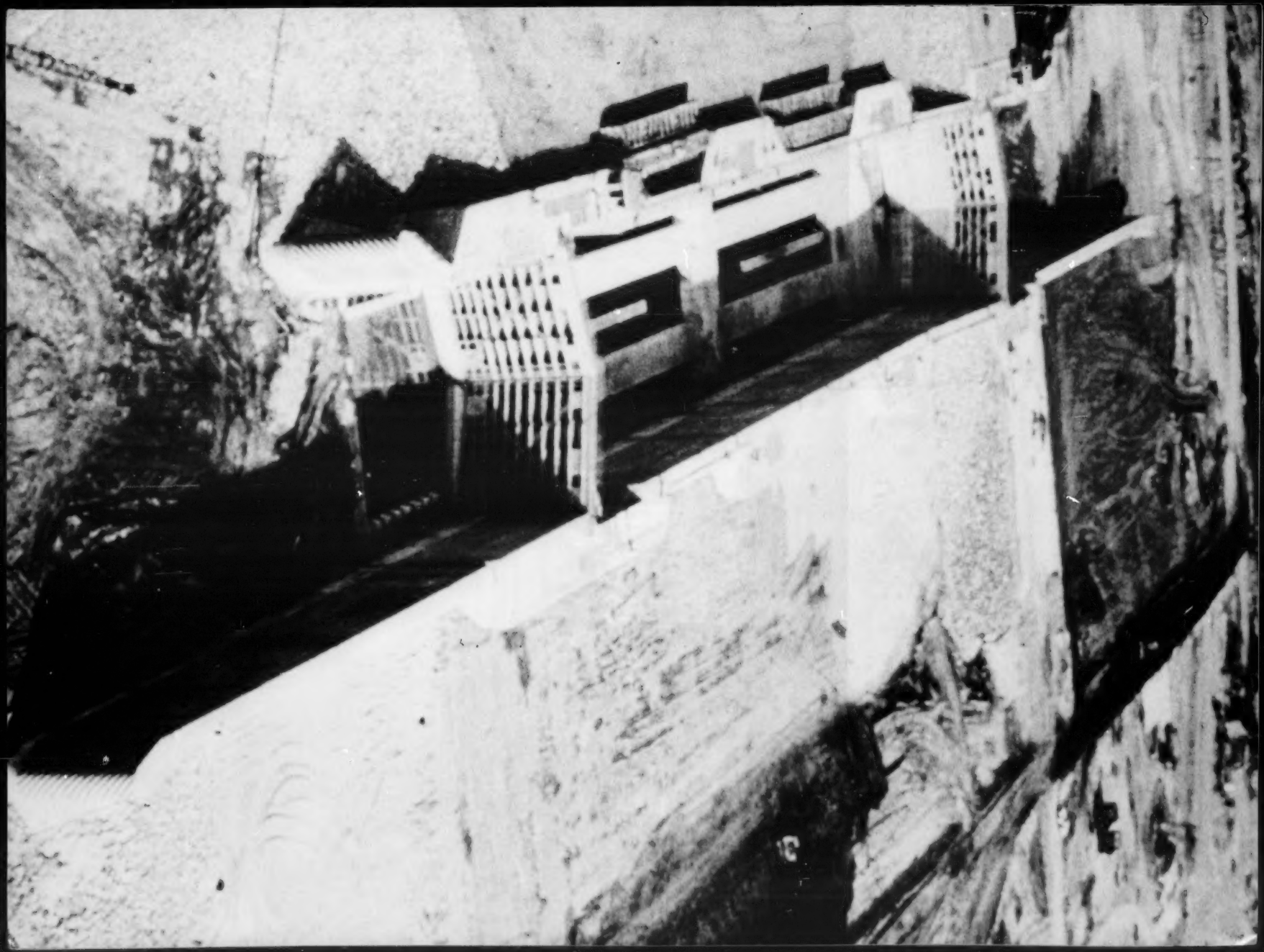
Political Structure

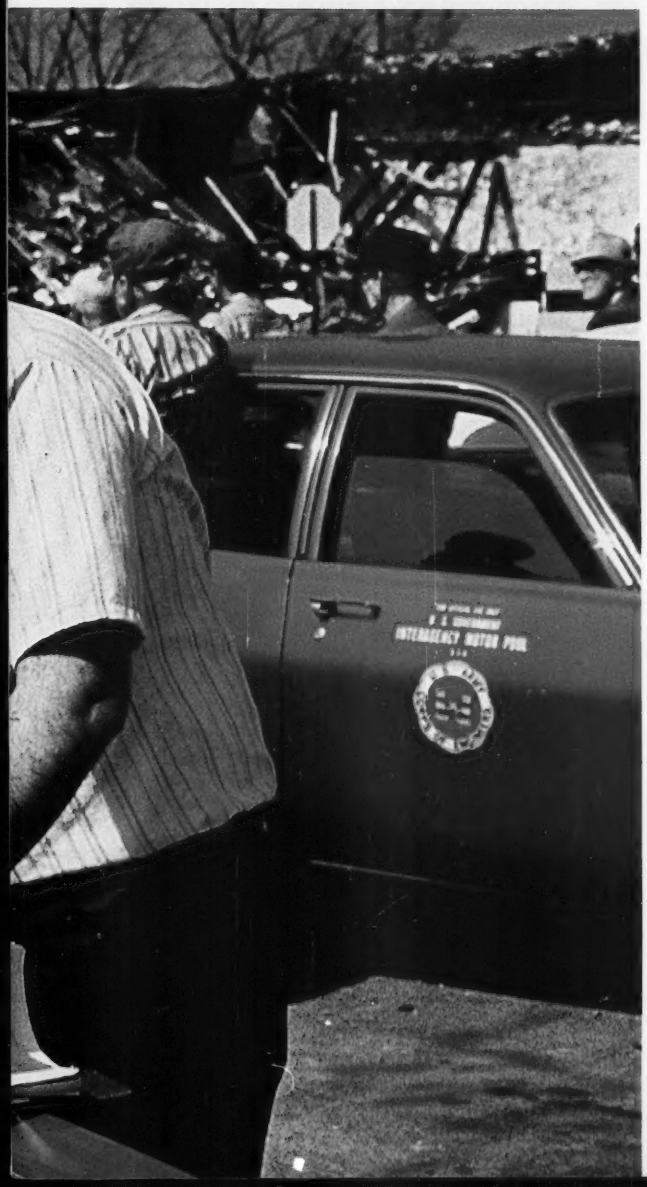
Supposedly, the Congress establishes policy and the President implements it. It doesn't always work that way. In the field of water resources development we now see the Congress concerning itself primarily with specific water resource projects while the President attempts to establish a national water policy. The drama is not new, however. Only the names of the cast change from time to time. Water resources development is the classic example of what some political scientists call distributive politics. It is characterized by legislative proponents of separate and unrelated projects, and by building consensus through what has (perhaps unkindly) been called "log rolling," or "mutual backscratching."

Distributive politics dominates whenever a program generates strong local interest because it is perceived to be a collection of local projects, rather than a unified national program serving a widely shared common interest. Such a perception is reinforced by generous cost-sharing rules which relieve local beneficiaries of the need to make hard choices because it is the Federal treasury, not their own scarce resources, which must foot most of the bill.

Strong local support for individual projects makes them attractive to legislators who are elected locally and who

Extensive negotiation is required before "proposed projects" become "construction starts."





seek to serve their constituents well. In fact, tests of the strength of local support occur repeatedly in the process through which water projects are developed and included in an authorization bill.

Water resources development is the classic example of . . . distributive politics.

At the national level, distributive politics comes to a head in the appropriation process. Proposed projects which have been planned and authorized form the pool from which new construction starts are chosen each year. Which of the waiting projects will become new starts is a matter of intense Congressional concern and a matter for much negotiation within the Congress and between the Congress and the President. However, this need not concern us here. Although many water conflicts occur over authorized projects, there is comparatively little freedom to substantially redesign an authorized project in order to find a solution which will diminish opposition. Conflict management should occur during preauthorization planning, when the institutional means for pursuing it should be available and the choice of alternatives should not have been made.

The Planning Process

Formally, Federal water resource planning begins when a member of Congress requests a feasibility study of a particular water resource problem in his district or state. The planning agency first conducts a reconnaissance and then completes the study if a solution seems feasible and justifiable. If the feasibility report is favorable, the planning agency may recommend authorization of a project described in some detail. This is preauthorization planning. The investigation does not get into detailed engineering design, a type of planning which occurs subsequent to authorization

Conflict avoidance may take the form of adding additional features to a project and increasing its acceptance.

and prior to and during construction. It does provide enough detail to permit evaluation of the merits of the proposed project.

The initial statement of the problem to be investigated is very important, because it sets the direction for all that follows and tends to limit the kinds of actions which will be explored and evaluated. Problems do not spring forth, fully developed, as Athene did from the head of Zeus. They begin with an experience of discontent which is very quickly converted into a possible action to relieve that discontent. It doesn't take long for someone with a toothache to focus upon calling a dentist. Similarly, it doesn't take long for a community which has just suffered a flood to think of flood protection measures.

The potential problem solutions which emerge are shaped by previous experience and by available information. If previous experience has been mostly characterized by levees, floodways, and dams, and if an engineering agency has already identified potential reservoir and levee locations, then it would be unusual for a problem not to be framed in terms of structural flood control solutions.

The potential for conflict gradually increases as the diversity and number of participants grows.

The language of the resolution with which planning begins may constrain the breadth of the subsequent investigation and of the alternatives considered. Even more constraining, however, is the restricted perception of the problem which is in the minds of local people from whom support for initiating and continuing the planning process must come. Investigations can be stimulated by comprehensive river basin planning as well as by local problem perceptions, but the momentum necessary to carry through to project authorization and appropriation of construction funding requires repeated evidence of strong local support.

The difficulty, of course, is that the broader the investigation and the less specific it is to what local people believe to be the preferred solution, the less likely it is to engender enthusiastic support. Conversely, the more specifically the investigation focuses upon the problem as perceived by local sponsors, the more obviously it emphasizes the alternative preferred by them, and the more effectively the cost-sharing rules transfer the burden of implementation onto the Federal treasury, the more likely that local enthusiasm can be sustained and increased.

Conflict Management in Planning

As planning proceeds, the number and diversity of participants increases. Some of these participants become involved because they have an official responsibility to do so. The Fish and Wildlife Coordination Act, for example, requires water resources development agencies to consult with and obtain the views of the U.S. Fish and Wildlife Service. State and local officials are also consulted and are asked to comment officially on recommended plans. Public hearings and other meetings, as well as media reporting, may attract other participants, although usually not until well along in the planning process. The potential for conflict gradually increases as the diversity and number of participants grows, and as more information on prospective project impacts becomes available.

Water planners can manage emerging conflict in several ways. If the project sponsors are enthusiastic and politically powerful, it may be possible to simply ignore some kinds of opposition. This approach is becoming less common, both because it violates the planning ethos and because the full disclosure requirements of the National Environmental Protection Act and other legislation make it more difficult.

Conflict avoidance, which is the traditional approach of distributive politics, provides another option. It involves adding more features to the project in order to include positive net benefits to a wider range of interests. To do so is to increase vital local support, particularly if some opponents can be converted to proponents in this way. Of course, it helps to have generous cost-sharing rules to facilitate this process. Many existing fish hatcheries and wildlife refuges would never have been established had they not been funded as mitigation provisions of Federal water development projects.

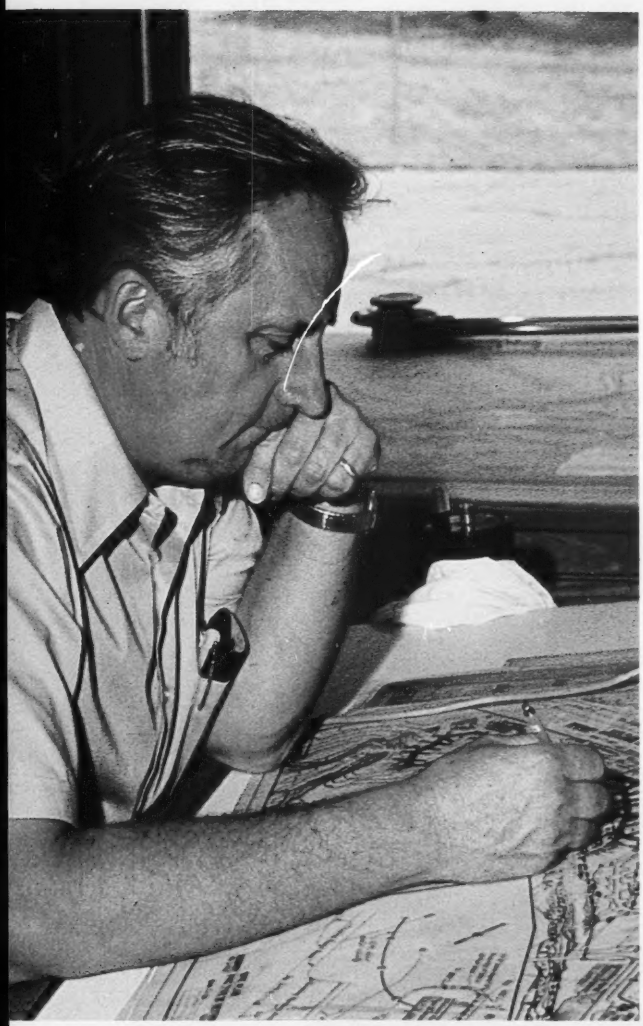
The difficulties with the distributive approach are twofold. First, even the generosity of the Federal treasury has its limits, thus restricting the extent to which additional support can be attracted through costly project add-ons. Second, the add-on nature of the approach works only so long as project components, and the interests they favor, can be kept reasonably separate, in the sense that benefits to one do not entail costs to another.

It may be that a new wildlife refuge will truly restore or improve game populations threatened by habitat reductions due to project construction. If so, including the refuge will effectively separate water resources development and wildlife considerations. Often, however, such separation is simply not technically possible. The distributive conflict avoidance approach of drawing upon the Federal treasury to make everyone (except the Federal taxpayer) a project beneficiary cannot be used if the technical options for doing so do not exist. Then there must be losers as well as winners, and conflict is unavoidable. Other conflict management techniques are needed. Just which technique will work best depends upon the type of conflict which predominates.

Conflict Types

Conflict situations differ in many ways. One source of difference lies in what the conflict is about, or what is at issue. Three of the several possibilities are particularly germane to water resources planning. Conflict can occur over factual or technical questions, it can occur over the broad social goals to be pursued, and it can occur over the direct impacts of proposed projects, i.e., over the incidence of prospective benefits and costs.

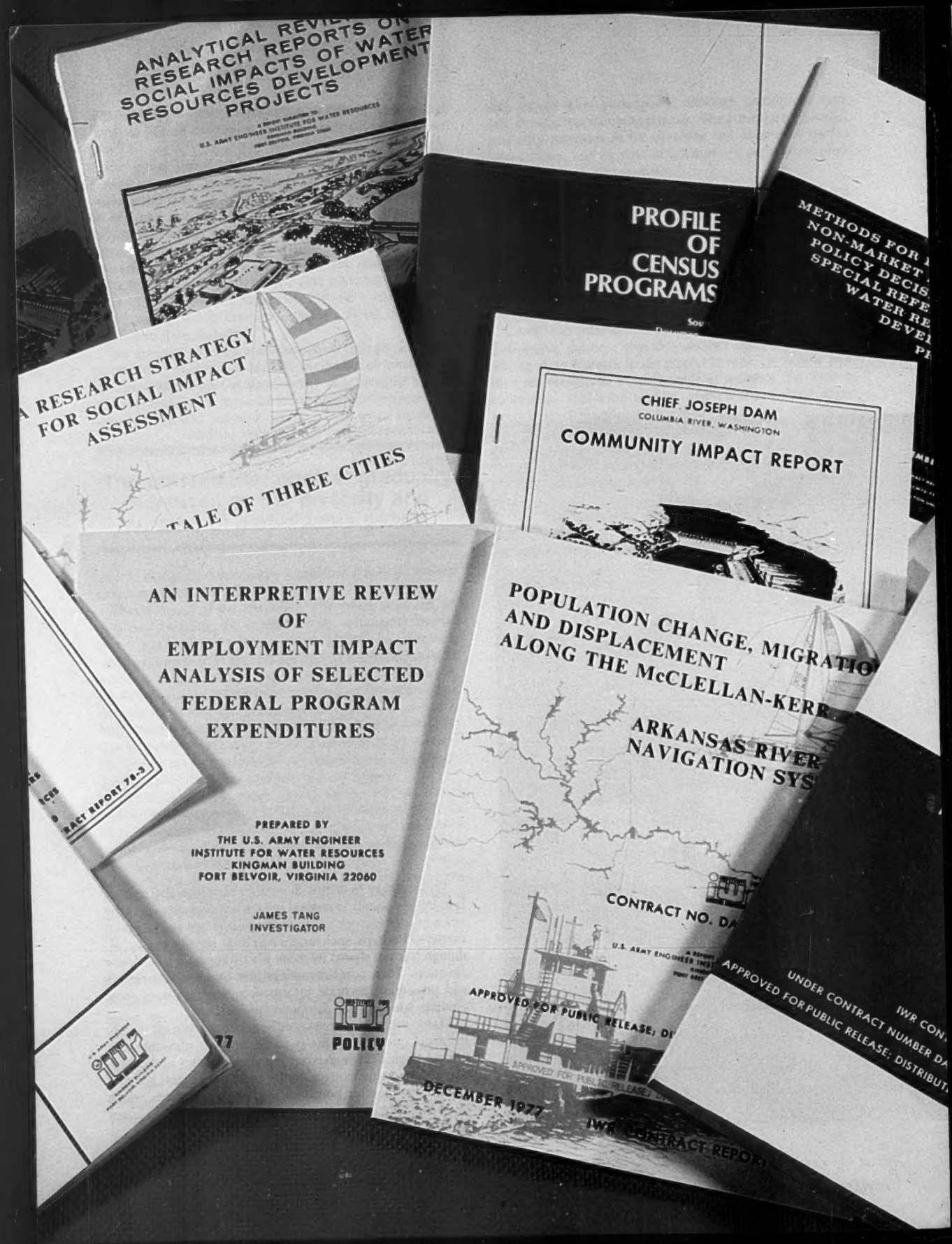
Projections or forecasts of what changes will occur if a particular action is taken are technical in nature. They are really statements that certain factual conditions do exist, or will exist under certain circumstances. Since they deal with matters of fact they can be tested and ultimately proven right or wrong, at least in principle.



Conflict management should occur during preauthorization planning, when alternative approaches are still available.

The best way to deal with conflict over technical matters is to invoke scientific method, which has evolved over many years to improve our understanding of factual and technical matters. Perhaps such understanding already exists, although it is not shared by those who disagree in a particular situation. Then conflict management involves assembling and presenting accurate information, possibly from more credible sources than parties to the conflict.

Many water resources conflicts occur over ostensibly technical questions. This is partly because planning as it is now done overemphasizes technical matters and underemphasizes value matters, to the point where facts smother values. Frequently, however, it is value questions which lie at the heart of the conflict, and scientific method is not an effective approach in such cases.


ANALYTICAL REVIEW OF RESEARCH REPORTS ON SOCIAL IMPACTS OF WATER RESOURCES DEVELOPMENT PROJECTS
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TALE OF THREE CITIES
CHIEF JOSEPH DAM
COLUMBIA RIVER, WASHINGTON
COMMUNITY IMPACT REPORT
AN INTERPRETIVE REVIEW OF EMPLOYMENT IMPACT ANALYSIS OF SELECTED FEDERAL PROGRAM EXPENDITURES
PREPARED BY
THE U.S. ARMY ENGINEER
INSTITUTE FOR WATER RESOURCES
KINGMAN BUILDING
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JAMES TANG
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Conflict over broad social goals or values is evident today in the debate over the relative emphases to be given to economic development and environmental protection in water resources decision making.

Disputes over social goals or values are not uncommon in water resources planning. Because they center upon issues of broad community, or even national concern, they are unlikely to be resolved within the context of planning particular water resources projects, or even within the context of water resources decision making in general. In fact, such matters are never resolved, in the same sense that other conflicts are resolved. Goals and social values do change, sometimes rapidly, but more often quite slowly. There is rarely a point which can be identified as the end of the debate.

The best way to deal with conflict over technical matters is to invoke scientific method.

Water resources planning must reflect current social goals and values. It will not determine those goals and values, certainly not as a matter of conflict management strategy, and only imperceptibly as a part of the much more general social process of value exploration and change.

Conflict over the incidence of prospective project impacts—who will gain and who will lose as a consequence of taking action—is the third important conflict type. This is also a kind of value conflict, in the sense that it occurs over what people want or desire, not over what is factually right or wrong. But it concerns the self-interest of individuals or groups, not the goals or values which we hold collectively.

Management of interest conflict requires bargaining between the affected parties to find a solution acceptable to all of them. Collective bargaining between labor and management is a good example. In water resources development, the planning agency can provide an institutional setting and an information base which facilitates the bargaining process. One requirement which should not be overlooked is sufficient institutional flexibility to shift the incidence of benefits and costs among participants in order to create an acceptable balance. One of the weaknesses of current planning is that efficient and technically superior alternatives for achieving social goals may be neglected due to unacceptable interest impacts. Creative institutional innovation could restructure those impacts to the benefit of all concerned, and thus make superior alternatives acceptable.

The planning process is long and involved, but is it totally responsive?

Conflict Management Prospects

How well can the predominantly distributive approach resolve current conflicts (e.g. developmental interests versus preservation interests) over water resources development? It can do quite well in resolving interest conflicts if two conditions can be met. First, the technical means of clearly defining what separates the goals of the contending interest groups must be available, that is, project options which satisfy one interest group without creating unacceptable costs for others must exist. Unfortunately, in an increasingly interdependent world, when both population growth and material progress increase interdependency, separation becomes more and more difficult and costly to achieve. Second, the institutional means of shifting the major costs of separation onto someone else (in most cases the Federal treasury) must be available. The willingness of the general taxpayer to pay the costs also seems to be diminishing. Thus it appears that the capability of distributively-oriented planning to resolve interest conflict is declining.

Distributively-oriented planning has never been well-suited to managing conflict over factual or technical issues. Indeed, it has created additional and irreconcilable conflict over such issues by attempting to justify distributively superior alternatives as economically desirable, or as otherwise technically efficient. But such justification is needed to rationalize the subsidies necessary for the distributive add-on technique of building local support and consensus. And, because this justification is not technically defensible, distributively-oriented planning does not dare to resort to disinterested and credible information sources which might be effective in resolving conflicts.

Full exploration of social goals and values is equally threatening in the context of distributively-oriented planning. Such goals and values are frequently invoked to justify distributive solutions, but those solutions are chosen on distributive grounds, and only by coincidence are they consistent with prevailing social goals and values. Nonetheless, they must be made to seem consistent with these generally accepted ends, and objective investigation can only threaten to expose the real inconsistencies which normally exist.

The objective grounds for conflict over water resources development have been increasing.

Even more inimical to effective conflict management is the need, in distributive decision making, to build strong local support and consensus behind a particular alternative early in the planning process. It effectively forecloses meaningful consideration of other alternatives later on, when enough information has been generated to reveal the real conflicts which, in principle, ought to be resolved rather than avoided. Our conclusion, then, is a pessimistic one. The objective grounds for conflict over water resources development have been increasing. This is true of social goals and values, of interest impacts, and even of technical aspects. Yet the structure of the water resources decision-making process, within which planning occurs, is primarily distributive. As such, it is capable of resolving only interest-based conflict, and then only under limited and increasingly uncommon circumstances. Only if that structure changes will the opportunity for effective conflict management present itself to water resources planners. The dilemma is that structural change is produced by changing public perceptions, which are in turn influenced by the kinds of information which planning can produce. To produce that information will intensify conflict in the short run, while creating the means for its resolution only in the long run. ■

The ultimate usage—and users—of a water resources project must be always in the planner's mind.

Building American Canals

Part II - From Erie to the Present

by Paul K. Walker

The decade of the 1830s saw remarkable developments in American transportation. Building upon the success of the Erie Canal—completed in 1825—canal-building fever swept the United States. Total canal mileage nearly tripled to more than 3,300 miles. The growth of railroads in this ten-year period was even more striking. Developers added three miles of new track for every two miles of canals to pull the train system virtually even with canals.

Private companies built the majority of canals but they could not have succeeded without the support they received from the states and the Federal government. Because civilian engineers were in short supply, transportation promoters relied on officers of the U.S. Army Corps of Engineers, the best trained engineers available. The assistance they provided was one form of government aid. In most cases engineer officers worked side by side with civilians.

The Army's role in the field of canal improvements actually began in 1823 when engineers helped survey canal routes in Delaware, Maryland, and New Jersey. At the time, General Simon Bernard and Colonel Joseph Totten, members of the Board of Engineers for Fortifications, expressed a strong commitment to canals. "Of all the means which human ingenuity has devised for facilitating communications between different parts of a country," they declared, "canals occupy, at the present day, the highest rank, and when well planned and judiciously located, they not only become sources of individual wealth; but they diffuse prosperity over extensive regions, and result in economy and advancement to the nation at large."

The Corps of Engineers' entry into the field of internal improvements became official with passage of the General Survey Act in 1824. The Act authorized the President to spend public funds to obtain surveys, plans, and estimates of routes for roads and canals that he deemed of national importance. Congress designated civil engineers and Corps officers to conduct the surveys. President James Monroe appointed a Board of Engineers for Internal Improvements, with Bernard and Totten and civilian engineer John L. Sullivan, as members, to carry out the Act. Drawing heavily upon the military for assistance, the Board initially employed three topographical engineers and three surveying parties. Within two years the number of engineer officers assigned to the Board had grown to 53 and the number of surveying parties to eight.

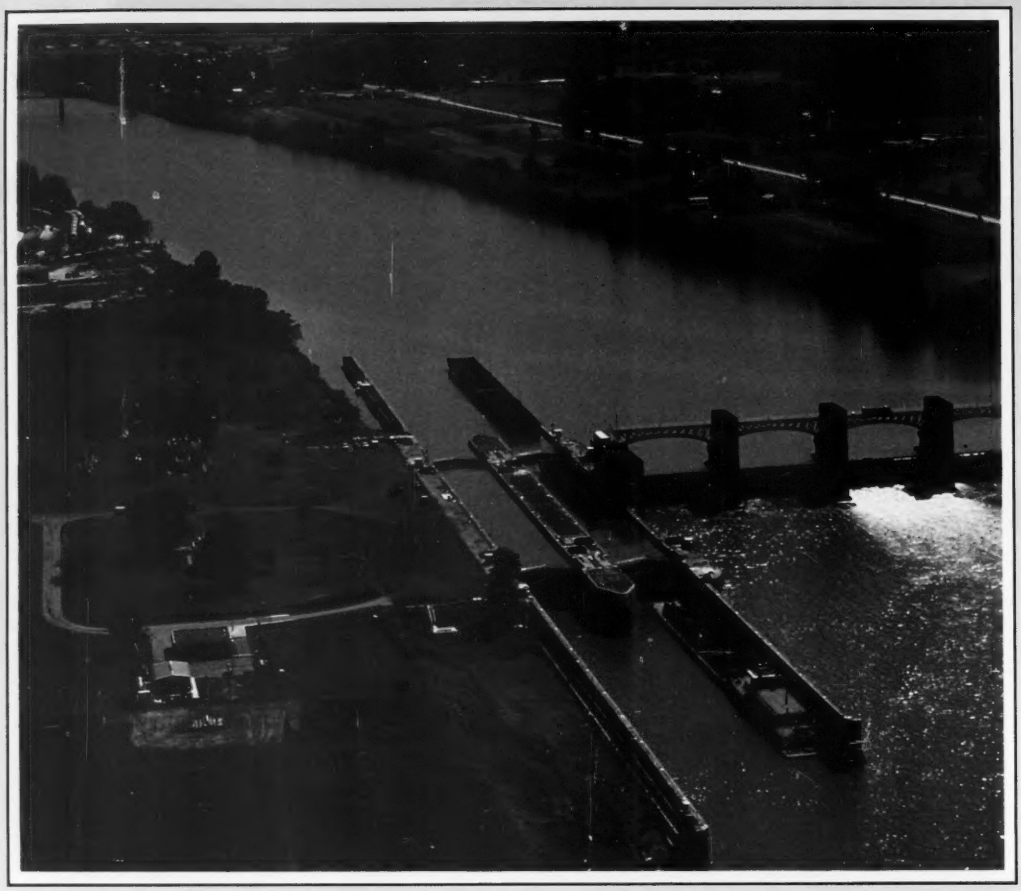
In its first year the Board focused attention on canals, rating 27 projects according to their military and commercial importance. So many survey applications flooded the White House and the War Department that available manpower became a factor in determining which projects received attention. Political considerations also weighed heavily. By 1827 the Board had completed 35 examinations and surveys. Nineteen were solely for canals, and three additional projects pertained in part to canals. One of the transportation routes envisioned by the Board of Engineers was a water passage from the Tennessee River to the Atlantic—later known as the "Southern Route." It utilized a series of canals to connect existing waterways. To complete this route it was necessary to circumnavigate the shallow, dangerous rapids on the Tennessee River called Muscle Shoals. In 1827 engineers surveyed the Shoals. Two years later, Lieutenant Colonel James Kearney drew plans for a bypass canal. He recommended a single structure 35 miles long estimated to cost $1.3 million.

In 1830 the State of Alabama commenced construction. Despite the advice of the Army that work should begin at Colbert Shoals downriver, the Alabama commissioners started digging at Big Muscle Shoals. They followed a set of plans stunningly detailed in watercolors by Nathan S. Roberts, designer of the high locks on the Erie Canal. Roberts' plans called for 16 locks with an overall lift of 86 feet. The canal at Big Muscle Shoals opened to traffic in 1837, but the subsidiary canals planned above and below this location were not finished.

The engineers made additional surveys of note in this period for the Chesapeake and Delaware, James River and Kanawha, and cross-Florida canals. When Congress phased the Board of Engineers for Internal Improvements out of existence in 1831, the Topographical Bureau took over the Army's survey work. The decline in popularity of canals near the end of the decade drastically reduced the Army's role in executing surveys, but the engineers found a new role for themselves as constructors. They built railroads, lighthouses, river and harbor works, and occasionally a canal. The knowledge that the Corps gained in the first half of the nineteenth century assured that whenever questions relating to waterways were raised their advice and participation would be sought.

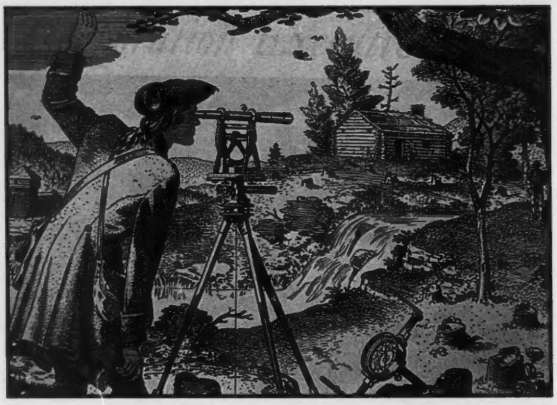
Lockport Lock, Illinois Waterway.

Dr. Walker is with the Historical Division, U.S. Army Corps of Engineers. He wishes to acknowledge the material provided by Dr. Leland Johnson in the preparation of this article. (Part 1 of this look at American canals appeared in the winter 79-80 issue of *Water Spectrum*—Vol. 12, No. 1.)

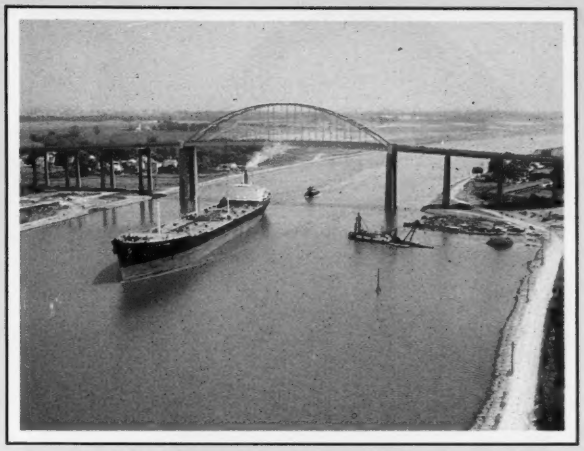


Canalization on the Kanawha River, Winfield Lock and Dam, West Virginia.

After 1840 construction advanced on the Miami and Erie, the Chesapeake and Ohio, and the James River and Kanawha canals. When the Saint Mary's Falls Canal opened in 1855, it formed a vital connection between Lake Superior and Lake Huron. But the number of abandoned canals exceeded those constructed. By the eve of the Civil War railroads as a mode of inland transportation had achieved preeminent status.



Several factors accounted for the rapid triumph of the railroads. In areas of heavy traffic involving long distances, shipping costs were at first clearly cheaper by rail than by road or canal, although this advantage was not so certain when railroad rates were compared to those on the largest canals. But in all cases railroads were more dependable than canals. Railroads were not generally subject to delays in service resulting from either excesses or shortages of water. Canals suffered such interruptions constantly. Moreover, a series of financial crises in the late 1830s hit canals hard, expected benefits proved illusory largely due to initially overinflated hopes, and feasible canal routes soon disappeared.



View of the Chesapeake and Delaware Ship Canal near St. George's Bridge.

A profitable canal-building endeavor required many favorable conditions. These included the ability to accommodate larger vessels, a near-capacity volume of traffic, efficient operation, and sound business management. Too many canal ventures lacked the right combination of these essential ingredients. The Pennsylvania Canal's main line enjoyed a longer operating season than the Erie, but the Pennsylvania operation suffered because its extensive lock system slowed traffic. Unpredictable droughts and floods menaced the Chesapeake and Ohio Canal in Maryland and the District of Columbia and others throughout Pennsylvania and Ohio. Nearly all artifical waterways proved inadequate to handle large vessels. As a result, more money was spent after 1840 to enlarge and improve existing canals than to construct new ones. The Erie, which had originally cost $10 million, required $44.5 million for improvements!

In the final decade before the Civil War, the Corps of Engineers also became involved with plans to achieve year-round river navigation through canalization. This process used locks and dams to establish slackwater pools. Canalization provided a river with a minimum channel like a canal, thereby permitting navigation during the low water season.

In the 1850s canalization focused on the Ohio River. William Milnor Roberts, a civil engineer active in canal and railroad construction and later placed in charge of Ohio River improvements by the Corps, argued in favor of adopting the locks and dams method on the Ohio. But, he encountered fierce opposition from proponents of a reservoir system. Before a final decision was reached, the Civil War intervened and disrupted waterways improvement activity.

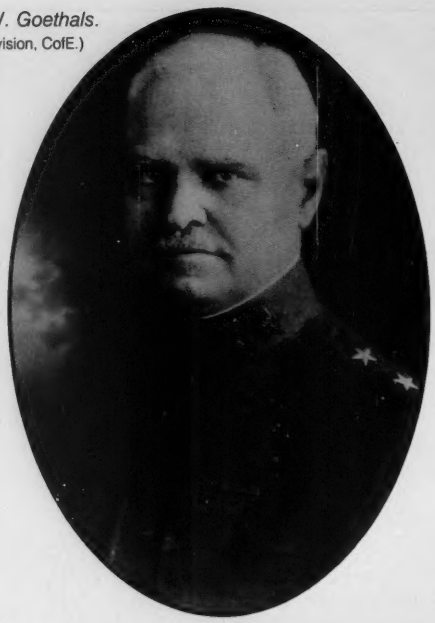
Railroads eclipsed canals in importance before the Civil War, but as one historian has pointed out, it should not be forgotten that some canals continued to enjoy prosperity in 1860, "and a few . . . did not reach their traffic peak until after the Civil War." In 1872 both the Erie and the Chesapeake and Delaware canals experienced their highest tonnage to date. Afterward, however, a decline also was noted on these popular routes.

Still, the appeal of waterways transportation persisted. In 1874 the Senate's Select Committee on Transportation Routes to the Seaboard, chaired by Senator William Windom of Minnesota, issued a report recommending the improvement of specific water routes to lessen overall transportation costs. In essence the committee saw competition from waterborne commerce as a means of checking railroad rates which were already deemed excessive. The committee envisioned a network of canals and of rivers improved through canalization.

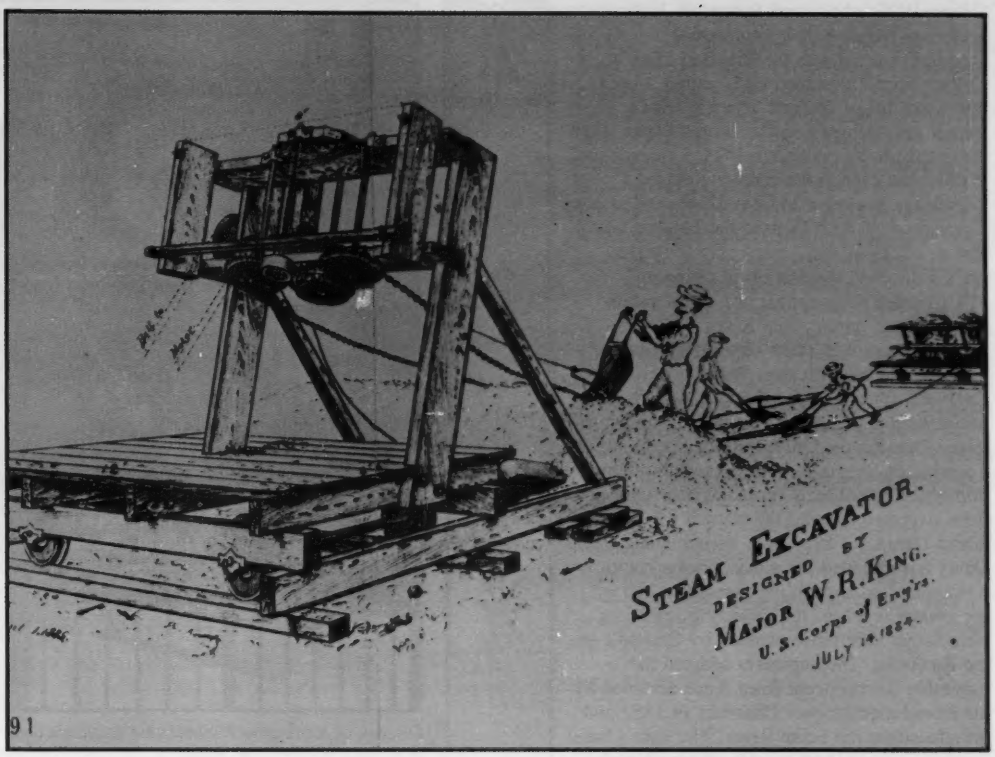
The Army engineers were at the center of activity as Congress redirected its attention toward inland waterways after the Civil War. Engineers testified before the Windom Committee. Their knowledge, gained from more than a half-century of first-hand experience with American waterways, provided information vital to the Senators' inquiry.

Once again a water passage from the Tennessee River to the Atlantic was among the projects recommended by the Windom Committee. In 1871 Major Walter McFarland,

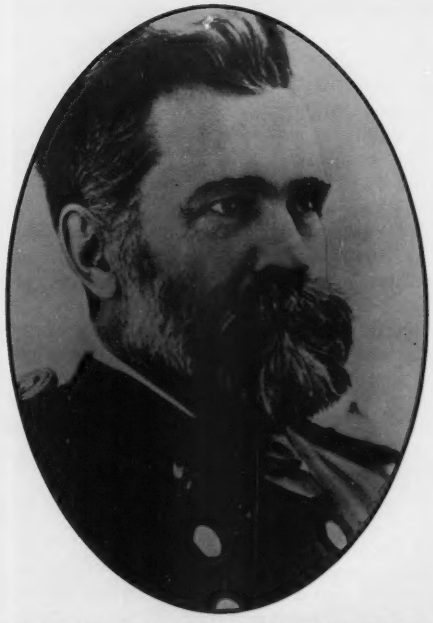
General George W. Goethals.
(Historical Division, CofE.)



Construction on the Muscle Shoals Canal, 1885.



Steam Excavator (Black and white photos courtesy of Nashville District, CofE, unless otherwise noted.)



Colonel William R. King, District Engineer during construction of the Muscle Shoals Canal, 1876-1886.

the engineer officer in charge of improvements on the Tennessee River, had initiated a new survey at Muscle Shoals. Despite suffering from the ravages of malaria, a group of 30 engineers led by McFarland completed the survey. They proposed to rebuild and expand the old canal and to add new canals at Elk River and Little Muscle Shoals located above and below the point known as Big Muscle Shoals. Testifying before the Windom Committee in 1874 with the new survey in hand, Major McFarland heartily endorsed the Southern Route, of which the Muscle Shoals improvements were an essential part.

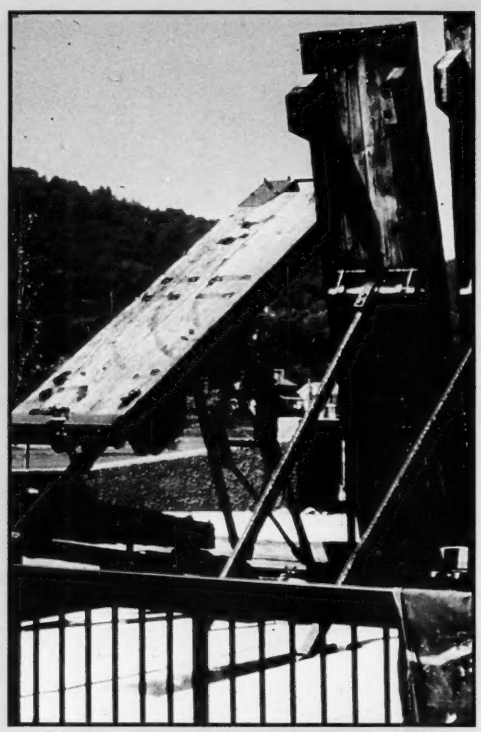
Beginning in 1875 and continuing for 15 years at Muscle Shoals, the Army engineers went beyond their more traditional role as surveyors to again become builders. Disease, floods, and sporadic appropriations plagued the project throughout, but several engineers launched highly successful careers from service at Muscle Shoals. The group included Major William Rice King, Lieutenants William Louis Marshall and

George W. Goethals, and Sydney B. Williamson, a civilian. Among their engineering accomplishments was the Riverton Lock at Colbert Shoals designed by Goethals with a low-water lift of 26 feet. The lift was the largest yet attempted in the United States when the canal finally opened in 1911. Goethals and Williamson carried the canal-building knowledge gained at Muscle Shoals and at later Corps projects with them to the Panama Canal.

As a direct outgrowth of the Windom Committee investigations, canalization finally began on the Ohio River. In 1875 Congress approved plans devised by General William P. Craighill, then Baltimore District Engineer, for canalizing the Kanawha, and Major William E. Merrill's plan for the Davis Island Dam on the Ohio south of Pittsburgh. Construction began on the Kanawha system immediately, but legal problems and opposition from rivermen delayed the start of the Davis Island Dam until late 1878. Merrill's design for Davis Island called for a masonry lock with a moveable dam and rolling gates. Because of the greater width of the Ohio, the structures were larger than those planned by Craighill on the Kanawha. The engineers adapted the moveable dam concept from those designed by the Frenchman Jacques Chanoine in 1852 and introduced on the Seine River. The dam's basic structure consisted of a series of long boards, or wickets, hinged to a masonry foundation. When the water level fell, a work crew pulled the wickets upright to create a slackwater pool. One advantage of this type of dam was that it preserved a virtually unobstructed channel that could be used during high water stages. This feature, it was hoped, would meet the objections of coal fleet operators who complained about the effect of canalization upon their livelihood.

Standard wooden locks with swinging gates were not suited to Ohio River barge traffic, which required lock chambers whose width exceeded 100 feet, so Merrill designed a rolling lock gate. The gate closed by moving on wheels over a track. He also planned lock chambers 600 feet long specifically to accommodate the coal barge tows using the Ohio. At the time they were opened, Merrill's Davis Island locks were the widest in the world. They exceeded those built at the Panama Canal in the early twentieth century.

In 1885 the Davis Island Dam opened with great fanfare, but the extension of canalization down the Ohio was still a long way off. Because it was the premier project on the Ohio River and raised amidst considerable controversy, the Davis Island Dam was built with great care. After it opened it became the



Display of Moveable Wickets at Hannibal Locks and Dam on the Ohio River.

testing ground for future undertakings on the Ohio River. Davis Island was the only canalization project introduced on the Ohio before the end of the nineteenth century. Progress on the Kanawha was more rapid. Craighill, assisted by a procession of talented engineer officers and civilians, saw ten locks and dams to completion by 1901.

The resurgence of interest in waterways represented by the Windom Committee inquiry in the 1870s steadily intensified and reached a crescendo early in the twentieth century. Critics continually cited the railroads for their high shipping rates. But even railroad tycoon James J. Hill welcomed the renewed interest in waterways and the support for canalling that accompanied it. In 1908 Hill told one waterways association that rails and waterways were "supplementary instead of mutually destructive." Such talk would have been unheard of a few decades earlier.

The waterways renaissance benefitted Ohio River canalization and in some cases breathed new life into dormant canal operations. In 1910 Congress appropriated funds for 54 locks and dams designed to create a nine-foot slackwater system on the Ohio from Pittsburgh to Cairo,

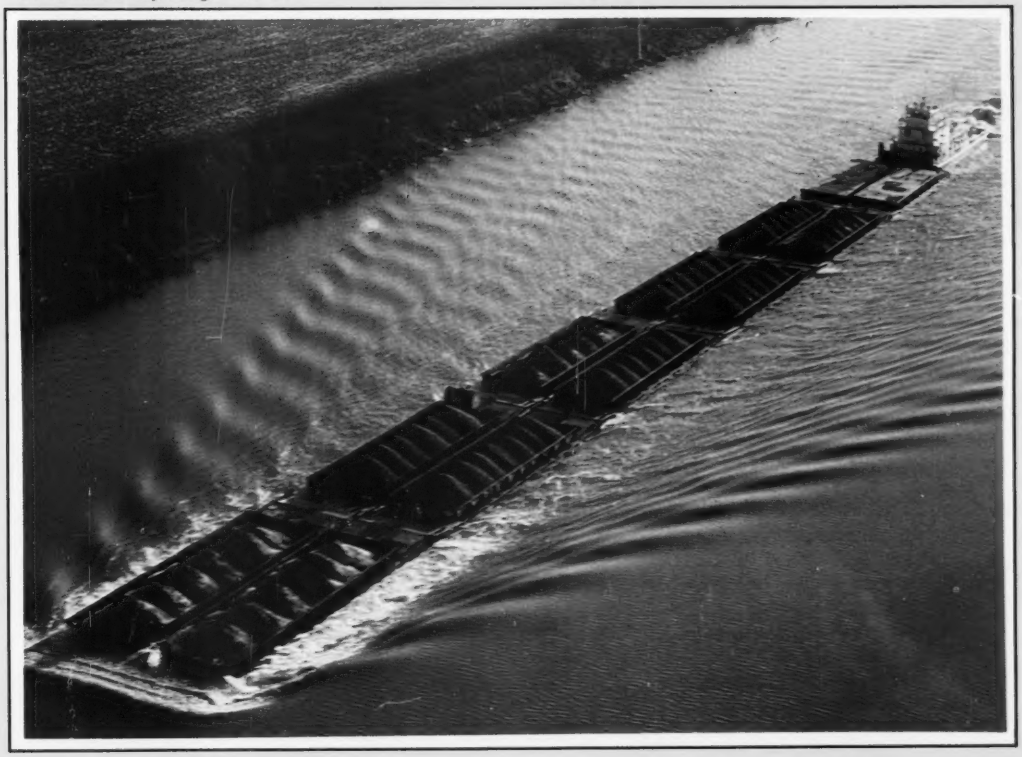
Illinois. Built at a cost of $125 million, the system opened in 1929. As the Corps of Engineers improved the Ohio, pressure mounted to deepen tributaries like the Kanawha which had smaller locks and a six-foot depth. A survey for the Kanawha was the first such project undertaken by the Corps' Huntington District after its creation in 1922.

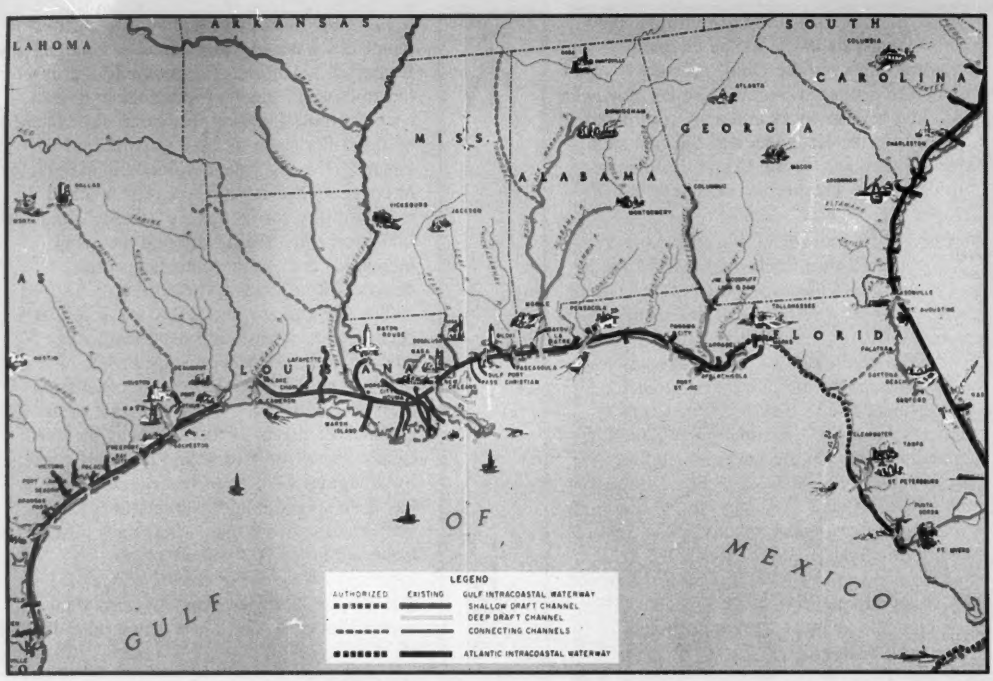
After 1894 a movement was underway to construct a ship (lock-free) canal linking the Delaware and Chesapeake bays. In 1906 President Theodore Roosevelt, one of the leading advocates of waterways improvement, appointed a committee to review alternatives for the Chesapeake and Delaware project. Major Clement A.F. Flagler of the Corps of Engineers served as a member. The committee eventually settled on a route following the existing lock canal. However, the Chesapeake and Delaware Canal Company lacked the funds to make necessary enlargements. Thus, in 1919, the Federal government decided to purchase the canal. The Wilmington District of the Corps of Engineers handled reconstruction that included a channel 12 feet deep and several new bridges.

From the outset the Wilmington District planned a waterway that could be enlarged still further in the future. The problems—primarily mudslides and shoals—which the engineers encountered rebuilding this canal were likened on a smaller scale to those experienced in Panama. Having once assumed the assignment to construct the canal, the Corps retained responsibility for its upkeep and for additional improvements. Traffic through the canal increased, and, as an immediate result, demands were made to enlarge it.

The Chesapeake and Delaware Ship Canal became part of an intercoastal waterway envisioned to connect existing bodies of water in a line roughly paralleling the coast from Boston south to Key West and west to the Rio Grande. Elements of the waterway included canals, canalized rivers, and channels deepened by dredging. Growth of the system generally has been sporadic and uncoordinated, but support dates from the earliest days of the General Survey Act when Congress appropriated funds for related projects, including a survey of possible canal routes across Florida to link the Atlantic with the Gulf of Mexico.

Inland Waterway Barge Traffic.





Map showing the Gulf Intracoastal Waterway.

After 1824 the Corps of Engineers conducted several Atlantic-Gulf canal surveys. But the Corps filed a negative report in each instance until the 1930s. Even then the project appeared in jeopardy. Debate focused on whether the canal should be built with or without locks and on its likely economic impact. Finally in 1935 President Franklin D. Roosevelt intervened and got Works Progress Administration funds for the project. Construction began in September 1935 but halted abruptly the following June. Mired in controversy, the cross-Florida canal had to wait until 1964 for the building to begin anew. Today the canal stands incomplete as a result of delays induced by spiraling costs and opposition from environmentalists.

In Texas the intercoastal waterway has been the responsibility of the Galveston District of the Corps of Engineers since its inception. On the Corps' recommendation, the Federal government purchased the Galveston and Brazos Canal from a private company in 1902. The canal joined Galveston Bay and the Brazos River and formed a major link in the waterway. To control sedimentation washing into the channel of the waterway, the Corps, in mid-century, built canal locks where the waterway intersected the Brazos and the Colorado rivers. At present, with major construction complete, maintenance of the waterway is the chief concern of the Galveston District.

Since World War II the United States has experienced sustained growth in the use of its waterways. This growth has fostered a continuing movement to upgrade the existing network. Locks and dams installed on the Ohio and Mississippi have proven in many cases unable to keep up with rising barge and shipping traffic. In an attempt to create longer and deeper slackwater pools to accommodate larger vessels, planners have abandoned the single-lock, wicket dams on the Ohio and introduced high-lift, non-navigable gated dams. The new locks are twice as long as the 600-foot structure at Davis Island. Generally one of the larger projects is sufficient to replace three or four of the existing smaller ones.

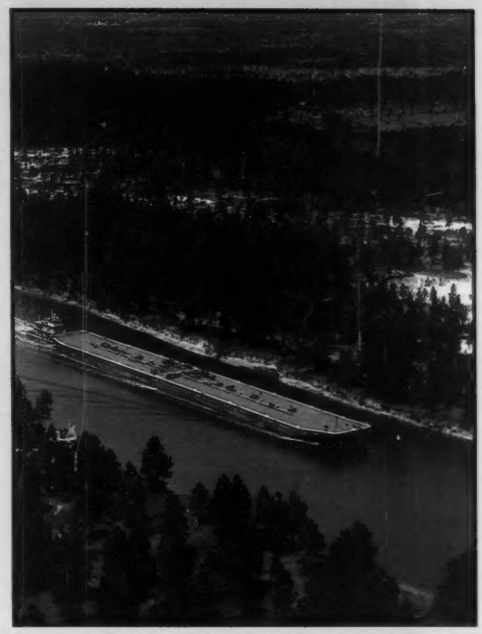
Rebuilding is also underway on the Mississippi where the Corps of Engineers initiated canalization shortly after the turn of the century and eventually completed 29 lock and dam facilities. Lock and Dam #26 on the Mississippi near Alton, Illinois, became the object of greatest attention. A severe shipping bottleneck resulted because the lock is located strategically between the lower Mississippi, Ohio, and Missouri rivers and the upper Mississippi and Illinois rivers. The St. Louis

District of the Corps of Engineers finished plans to remodel L&D #26 in the early 1970s, but railroads and environmentalists brought suit and delayed the start until 1978.

Post-war shipping trends encouraged fulfillment of the longstanding dream to complete a Southern Route. In response, the Corps of Engineers embarked on the Tennessee-Tombigbee Waterway, which actually follows one of several alternative routes first proposed in the 1820s. Tenn-Tom, as it is popularly known, is the largest canal-building venture, both in terms of size and cost, in the history of Federal navigation projects. Tenn-Tom stretches for 232 miles, and includes an improved channel section with four locks and dams, a five-lock, 45-mile canal, and a 27-mile divide section with a high lock and dam cutting through the hills which separate the Tennessee and Tombigbee river basins. The ten locks on the waterway will have a combined lift of 341 feet.

Canalization on the Cumberland River, Construction of Lock #1, 1891.

Congress initially authorized funds for a Corps' study in 1946, but disputes over the cost-benefit ratio delayed construction for



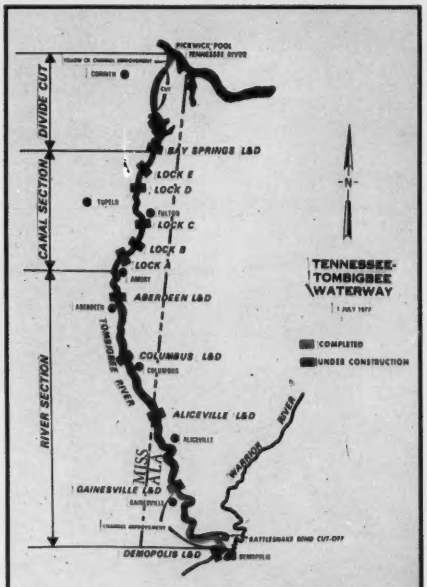
Canal South of the Divide Section, Tennessee-Tombigbee Waterway.

25 years. After the digging began, the Louisville and Nashville Railroad and environmentalists carried on the attack against the Tenn-Tom. They charged that the Corps had improperly computed a favorable cost-benefit ratio and was knowingly exceeding the channel width originally authorized by Congress. Thus far the courts have ruled in favor of Tenn-Tom and the Corps, and, despite occasional threats, Congress has not cut off funds. Construction continues at a rate presently running two years ahead of schedule. The project's supporters insist that its impact on the economies of Alabama and Mississippi—and on commercial barge traffic in general—will be substantial. Detractors maintain that Tenn-Tom is a colossal waste of money.

Land Cut on the Gulf Intracoastal Waterway.

Increased shipping in the last several decades has also fostered a major effort to open navigation for ocean-going vessels as far as Chicago via the St. Lawrence River and Lake Erie. A joint U.S.-Canadian effort, the St. Lawrence Seaway includes a ten-mile canal—the Long Sault—near Massena, New York. In September 1954 the St. Lawrence Seaway Corporation named the Corps as construction agent for the Long Sault Canal. The Buffalo District directed the effort with the support of several Corps field offices. More recently the engineers undertook studies to open the Seaway to year-round navigation and began upgrading the Illinois Waterway, thereby carrying the St. Lawrence connection to the Mississippi. In Oklahoma and Arkansas the Corps is employing newly-cut canals and canalization techniques to link the McClellan-Kerr Navigation System with the Mississippi and make ports of cities such as Little Rock and Tulsa.

More than a century and a half has passed since the completion of the Erie Canal. American economic development in that period has demonstrated that while canals are not the key they once, briefly, were thought to be, they are nevertheless an important factor in



Tennessee-Tombigbee Waterway.

Coal Barges Locking Through at McAlpine Lock on the Ohio River at Louisville.

Port of Catoosa, Oklahoma, at the head of navigation on the Verdigris River, McClellan-Kerr Waterway.

achieving unimpeded inland navigation. Canals effectively close the gaps and bypass the obstructions left by nature in our waterways network. And the employment of canal-building technology to deepen rivers through canalization has been equally successful. This is a decade of energy crisis. Transportation costs concern us. The coal industry is undergoing a renaissance. In such circumstances, plans for the future will continue to focus on our inland waterways, and on the canals that are a part of that system. ■

short take: BOATING THE ATLANTIC INTRACOASTAL WATERWAY

by **Robert N. Saveland**

Any literature search reveals a comparative paucity of articles related to environmental and management problems associated with recreational boating on the Atlantic Intracoastal Waterway. Various Federal and state agencies, commissions, special interest groups, authorities, and private companies indirectly manage the Waterway through regulations, funding and environmental protection.

Environmental Issues

The Environmental Protection Agency (EPA) is a governmental organization with a management function affecting the Intracoastal Waterway. The Federal Water Pollution Control Act of 1972 directed the EPA to take steps toward the goal of eliminating all untreated discharges into navigable waters by 1985. Of direct concern to the recreational boater are Coast Guard regulations issued under EPA guidelines to control marine sanitation devices (MSD's) aboard boats. Regulations originally intended to go into effect in 1975 had to be postponed until January 30, 1980 because of the inability of the boating public to comply. A survey by *Cruising World* evoked considerable response on this subject. Eighty percent of the respondents rated government efforts to handle pollution attributable to small boat owners as "bad." Ninety percent indicated that they were concerned about pollution. The regulations are retroactive to boats built before 1975, and it is estimated that 125,000 to 250,000 boat owners must still install a macerator/chlorinator, a biological digestor, or a holding tank in order to comply. Costs can range from $100 to $1,000 for the various devices, and often the components or hardware are not readily available. The Coast Guard is empowered to enforce the law and flagrant violations can carry fines of up to $2,000.

Concomitant with the installation of holding tanks on pleasure boats has been the need to establish pumpout stations at marinas. In order to amortize the costs, it is necessary to charge a fee for this disagreeable service. Boats returning on weekends can cause congestion at the pumpout station.

Much of the work on the waterway was done before states passed marshland protection laws, or before there was much public concern about the dumping of dredge spoil. In several lagoons, islands were created with spoil and these have subsequently become covered by vegetation. The Florida Audubon Society, in cooperation with the Florida Inland Navigation District, has established and maintained wildlife sanctuaries along the waterway on the spoil areas. Since the waterway parallels a major flyway for migrating birds, it is a great place for bird-watching. Other wildlife refuges are located along the waterway in the states to the north.

Powerlines must also transit the waterway, either high overhead or in cables across the bottom. Signs warn boatmen not to anchor near power cables. Utilities seeking to extend new lines across the waterway have to deal with several agencies—the Corps of Engineers, the Coast Guard, the State Department of Natural Resources, port authorities, and local governments. In addition, they must file environmental impact statements and arrange easements with individual property owners. These procedures reflect where we are today in terms of environmental protection and safeguards.

Marinas

As can be expected, environmental and management problems intensify in areas where recreational boating is concentrated. Desirable marinas and yacht clubs in urban centers may have long waiting lists for slips. Several cities such as Charleston and Beaufort in South Carolina, and St. Augustine, Daytona Beach, Fort Pierce, and Fort Lauderdale in Florida, have municipal marinas with some spaces reserved to accommodate transient yachtsmen.

A great migration takes place each fall and spring as yachts are shuttled between northern and southern waters. This, along with commercial fishermen, comprises more than half the traffic on the waterway.

Marinas are being faced with escalating land values and increased property taxes. It is ironic that large numbers of pleasure boats are taxed by the local government where the owner resides, often an inland area which provides no services whatsoever for the boat. Marinas face competition from developers, and zoning changes and re-evaluation can force them out, as in the case of the Chevron Marina in Fort Lauderdale and Riegel's boatyard in Sarasota. Even anchorage is pitifully scarce in Fort Lauderdale, and a trip on the waterway there is a constant rocking as powerboat wakes reverberate off the seawalls on either side. On all the narrow portions of the waterway, bank erosion from boat wakes

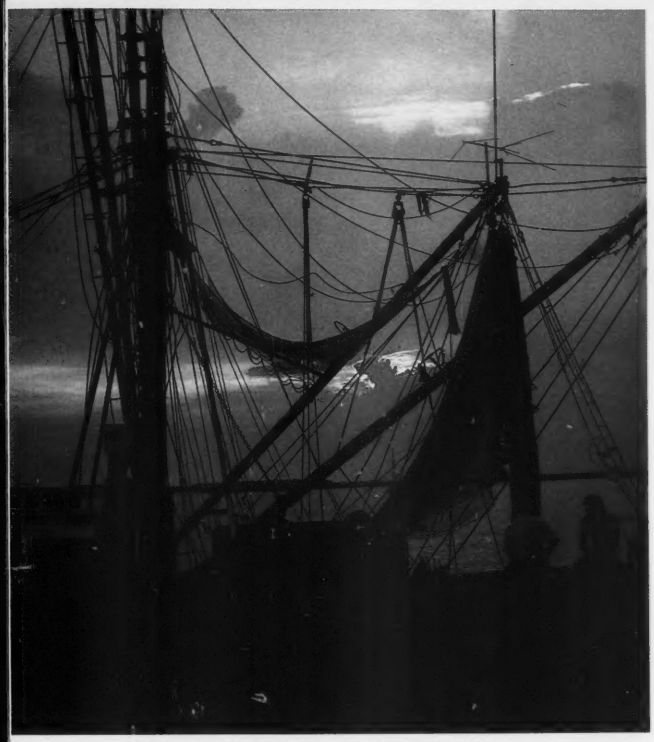
Marina on Jekyll Island, Georgia. Photos by the author

Dr. Saveland is Professor of Social Science Education, University of Georgia, Athens.

is an continual problem, and "no wake" signs are frequently ignored.

Safety

With increasing numbers of small boats using the waterway, problems of boating safety have intensified. The Department of Natural Resources in the various states usually registers boats and maintains patrol boats to enforce state water safety laws. On the national level, this function is exercised by the U.S. Coast Guard which also performs rescue services. Civilian voluntary members of the U.S. Guard Auxiliary inspect and approve the safety equipment on pleasure boats, and come to the aid of yachtsmen in trouble. A tragic accident on the waterway in October 1978 saddened and embarrassed the Coast Guard when the Cutter *Cuyahoga* was rammed by the coal freighter *Santa Cruz II*, with the loss of 11 lives. This incident not only demonstrated human fallibility, but also pointed up the fact that smaller vessels should stay out of the way of big ships.



Shrimpers at sunset.

Weather conditions are closely related to problems of boating safety. Boats equipped with VHF radios may receive weather alerts and notices to mariners from the Coast Guard via channel 16, or they may pick up one or two of the continuous forecasts broadcast by the National Weather Service, a division of the National Oceanic and Atmospheric Administration (NOAA). A problem with the NOAA forecasts is that they are generalized for 5,000 to 15,000 square mile zones and the conditions experienced by the boater may be at considerable variance with what he is hearing on the taped broadcast. Hurricanes, waterspouts, severe thunderstorms, and full gales are meteorological problems to be encountered on the Atlantic Intracoastal Waterway.

The United States Power Squadron with more than 425 squadrons across the country promotes boating safety through education. Their current 10-week basic course includes boat handling, compass and chart work, seamanship, and trailering. Advanced piloting, seamanship, and navigation courses are also offered.

Bridges

In 1960 the Corps of Engineers established a minimum clearance for fixed bridges across the waterway at 65 feet. These clearances were adopted by the Coast Guard when the bridge building function was transferred to the Department of Transportation in 1966. At the present time there are 19 fixed bridges in place or under construction across the waterway within the Seventh Coast Guard District (Florida, Georgia, and South Carolina). Their average cost is about $4 million. Such bridges eliminate the need for stopping traffic in either direction, but they do take additional space with their graded approaches.

What About the Future?

Accounts of travel on the waterway reveal that some areas have changed very little in the last 40 years, whereas others have undergone galloping development. Barring tsunami or hurricane, subdivisions built since World War II are apt to be around at the turn of the next century. Additional developments like Hilton Head and Kiawah are underway, and more highrise condominiums may overlook the waterway, but their environmental impact will first be studied. Barring accident, the Turkey Point nuclear powerplant along the waterway on Biscayne Bay will still be there, but one wonders about the ultimate disposal of the structures when the plant is no longer of service. Other nuclear powerplants are under construction adjacent to the waterway near Fort Pierce, Florida, and on the northern end of Key Largo.

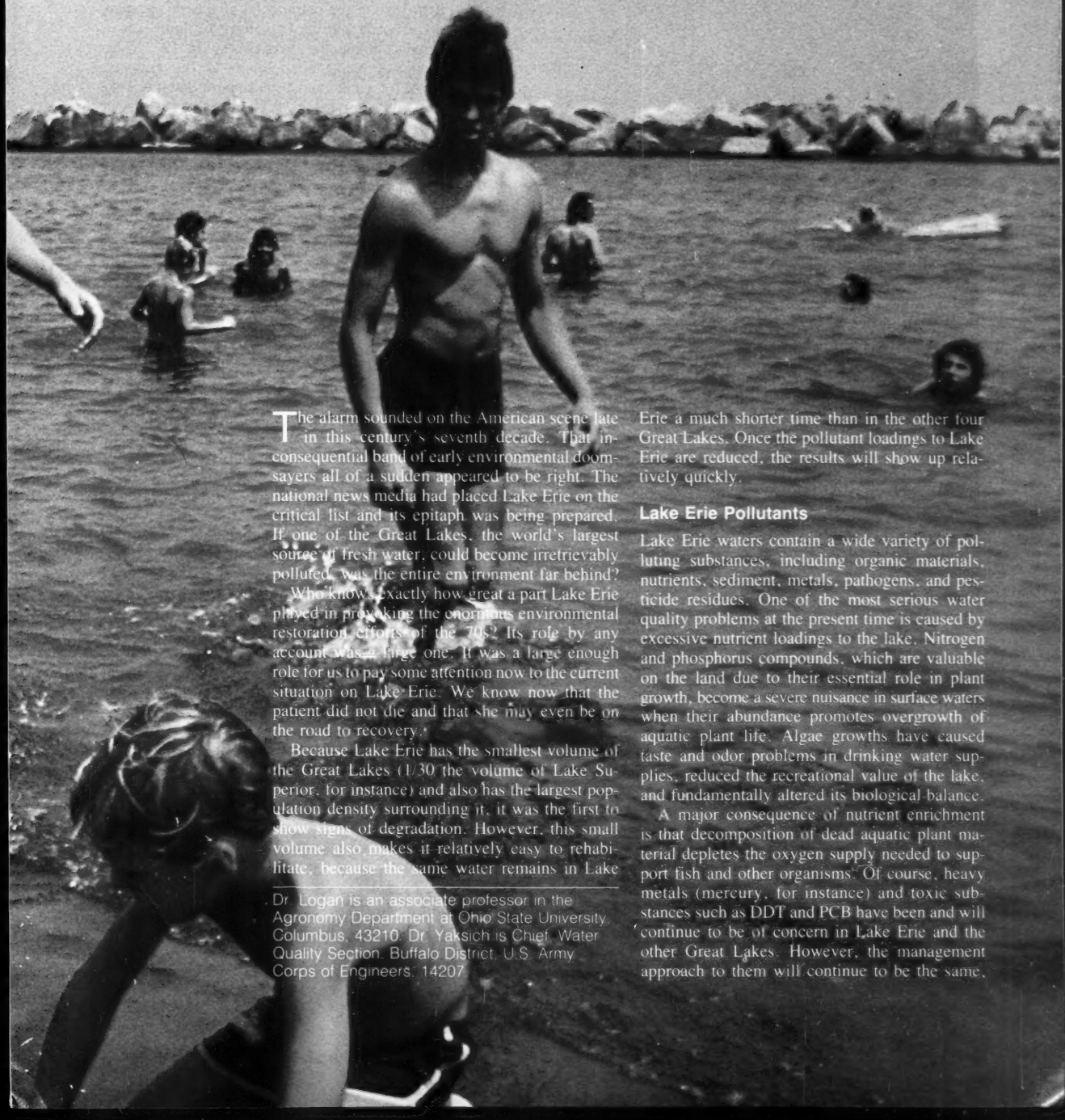
The "boating explosion" seems destined to continue as more young people have opportunities for boating experiences. There are now in the United States some 50 million boaters, and the boating population is increasing by 10 percent a year. Trailer boating is growing in popularity and ramps and launching facilities are crowded on weekends. With the rising cost of gasoline, more boaters are becoming interested in sailing. The general direction of land-sea breezes and prevailing winds often makes it possible to sail on the waterway.

Water quality on the waterway has improved in the last decade as municipalities have built sewer treatment plants, and factories have gone to secondary and tertiary processing of their waste water. The waterway is now swimmable in some cities, especially where the tides perform a flushing action. Hopefully another decade will find the water of swimming quality everywhere and in the next century there will still be places where boaters can drop a hook and spend hours in solitude with only the sounds of nature about them. For those portions of the waterway which must be developed, may men and women apply intelligence when regulating recreational boating so that living, working, and playing along the waterway may be a worthy, satisfying, and aesthetically beautiful experience. ■

Despite its problems, Lake Erie continues to be a valuable recreation resource

Lake Erie: A New Prognosis

by **Terry J. Logan and Stephen M. Yaksich**



The alarm sounded on the American scene late in this century's seventh decade. That inconsequential band of early environmental doomsayers all of a sudden appeared to be right. The national news media had placed Lake Erie on the critical list and its epitaph was being prepared. If one of the Great Lakes, the world's largest source of fresh water, could become irretrievably polluted, was the entire environment far behind?

Who knows exactly how great a part Lake Erie played in provoking the enormous environmental restoration efforts of the 70s? Its role by any account was a large one. It was a large enough role for us to pay some attention now to the current situation on Lake Erie. We know now that the patient did not die and that she may even be on the road to recovery.

Because Lake Erie has the smallest volume of the Great Lakes (1/30 the volume of Lake Superior, for instance) and also has the largest population density surrounding it, it was the first to show signs of degradation. However, this small volume also makes it relatively easy to rehabilitate, because the same water remains in Lake Erie a much shorter time than in the other four Great Lakes. Once the pollutant loadings to Lake Erie are reduced, the results will show up relatively quickly.

Dr. Logan is an associate professor in the Agronomy Department at Ohio State University, Columbus, 43210. Dr. Yaksich is Chief, Water Quality Section, Buffalo District, U.S. Army Corps of Engineers, 14207.

Lake Erie Pollutants

Lake Erie waters contain a wide variety of polluting substances, including organic materials, nutrients, sediment, metals, pathogens, and pesticide residues. One of the most serious water quality problems at the present time is caused by excessive nutrient loadings to the lake. Nitrogen and phosphorus compounds, which are valuable on the land due to their essential role in plant growth, become a severe nuisance in surface waters when their abundance promotes overgrowth of aquatic plant life. Algae growths have caused taste and odor problems in drinking water supplies, reduced the recreational value of the lake, and fundamentally altered its biological balance.

A major consequence of nutrient enrichment is that decomposition of dead aquatic plant material depletes the oxygen supply needed to support fish and other organisms. Of course, heavy metals (mercury, for instance) and toxic substances such as DDT and PCB have been and will continue to be of concern in Lake Erie and the other Great Lakes. However, the management approach to them will continue to be the same.

either a ban on the use of the material or a ban on release of the material to the lake and the pathways to the lake. It is control of the nutrient pollutants that presents the real problem. Their growth-inducing characteristics make them valuable to the drainage area inhabitants. Specifically, research has indicated that phosphorus is the nutrient most responsible for Lake Erie's water quality problems.

Phosphorus Control

Recognizing the detrimental effects of phosphorus, Canada and the U.S. have set limits for its introduction into the Great Lakes. The 1972 Water Quality Agreement between the two governments called for a reduction of phosphorus loads to Lake Erie until they reach 16,100 metric tons a year. The 1978 supplemental agreement set the goal even lower, at 11,000 metric tons a year. It is estimated that this reduction will essentially eliminate the oxygen depletion problem in the central basin of Lake Erie; an area that contains 63 percent of the lake's volume. The central basin also experiences the worst oxygen depletion problems.

Before a plan for phosphorous control could be developed, certain basic information was needed about the sources of the phosphorus which enters Lake Erie. Research done by the Corps of Engineers' Lake Erie Wastewater Management Study team indicates that, as an average, somewhere around 20,000 metric tons of phosphorus enters the lake each year. Of this, only about 10 to 15 percent comes from the upper Great Lakes or the atmosphere. The rest comes from Lake Erie's own drainage basin. Within this basin, phosphorus pollution is either the result of municipal and industrial wastewater outfalls, called "point sources," or runoff from widespread areas, called "diffuse sources."

The effort to reduce point source phosphorus has been underway since the early 1970s. By August 1977, over $900 million had been spent for construction of municipal sewage treatment plants in the Lake Erie basin. The 1978 Water Quality Agreements call for municipal treatment plants discharging over 1 million gallons per day to be releasing only ½ a milligram of phosphorus per liter by the end of 1982. The solution to point source phosphorous pollution clearly seems to lie in treatment facilities.

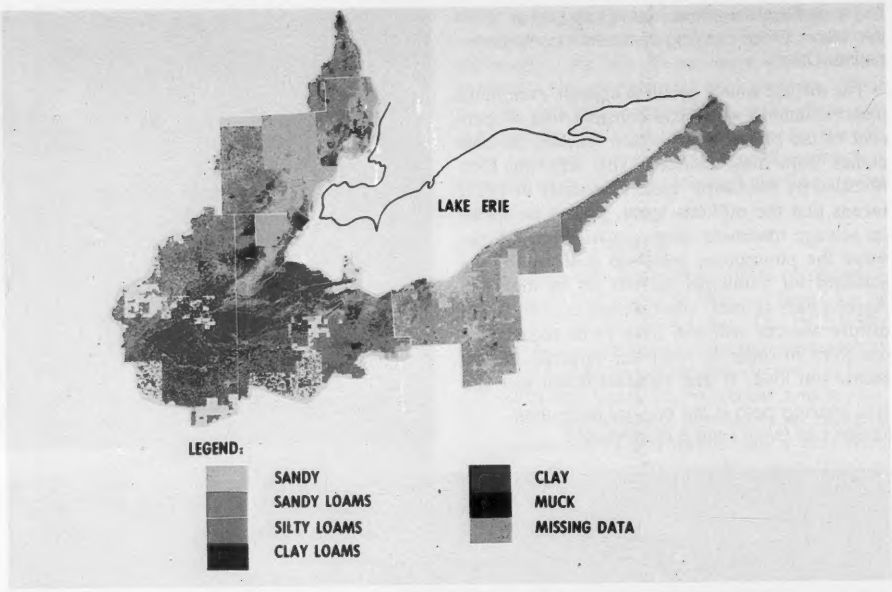
The answer to diffuse source pollution is hardly so simple. In this case, the phosphorus is coming from a large area—rather than from man-made structures which can be controlled. Urban diffuse source areas are somewhat controllable via city storm sewer systems, but rural diffuse source areas cover thousands of square miles, making structural pollution control infeasible.

The result of overenrichment of Lake Erie—algae builds up along the shore.

The Vermillion River flows into Lake Erie at Vermillion, Ohio, carrying sediments from north central Ohio.

The diffuse source problem appears even more insurmountable when you consider that 44 percent of the phosphorous which reaches the lake comes from these sources. This sobering fact, revealed by the Corps' Lake Erie study in 1977, means that the millions spent, and to be spent, on sewage treatment plant construction will not solve the phosphorus pollution problem. If the standard for municipal outfalls set by the 1978 Agreements is met, phosphorus coming from diffuse sources will still have to be reduced by one-third in order to reach the targeted 11,000 metric ton load. If that standard is not met and

This snaking path is the escape route that topsoil has taken from a plowed field.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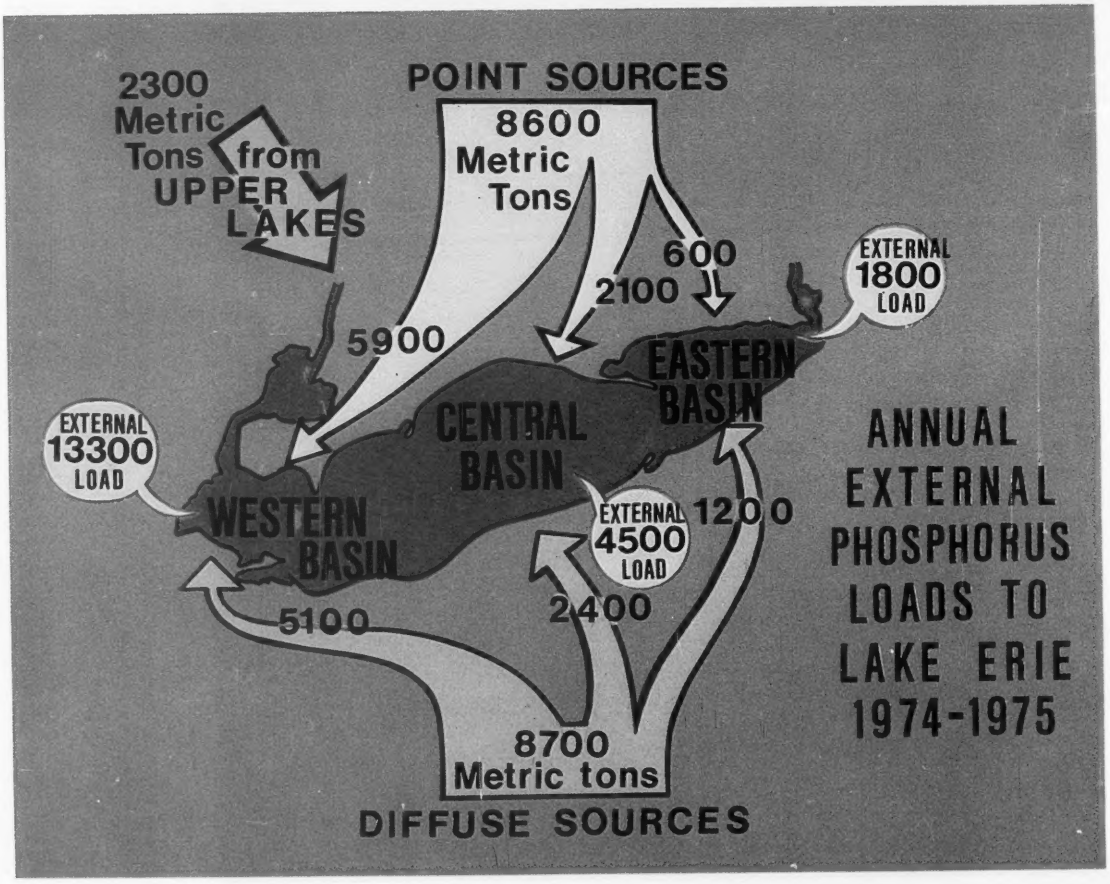

POINT SOURCES
2300 Metric Tons from UPPER LAKES
8600 Metric Tons
600
2100
EXTERNAL 1800 LOAD
5900
EASTERN BASIN
CENTRAL BASIN
EXTERNAL 13300 LOAD
WESTERN BASIN
EXTERNAL 4500 LOAD
1200
5100
2400
8700 Metric tons
DIFFUSE SOURCES
ANNUAL EXTERNAL PHOSPHORUS LOADS TO LAKE ERIE 1974-1975

This map, an example of the type of information being developed to help fight diffuse source pollution, shows the surface texture of soils in the U.S. Lake Erie drainage basin.

only a 1 milligram per liter concentration is achieved, diffuse source phosphorus will have to be reduced by almost one-half.

Phosphorus Transport

Phosphorus enters Lake Erie and its tributaries from a number of diffuse sources, including urban areas, individual septic systems, solid waste disposal areas and farmlands. Since agricultural activity is the predominant land use in the Lake Erie drainage basin, farmlands contribute the most phosphorus of all diffuse sources. Although some phosphorus comes from agricultural livestock operations, the primary agricultural activity that contributes phosphorus is crop production.

Phosphorus is contained in the fertilizer and manure that are spread on the land to assist crop growth. It possesses a strong affinity for soil particles and quickly becomes attached to them, although some phosphorus may leach into the groundwater. Over-fertilization results in more leaching as the soil becomes filled with the attached phosphorus. The leached phosphorus becomes dissolved and flows in the groundwater to the Lake Erie tributary system. The soil-attached (particulate) phosphorus reaches nearby streams through the soil erosion process. Rainstorms dislodge the soil particles and carry them to the streams, where they become the sediment that is transported through the tributary system to Lake Erie. Although the ratio varies for different regions in the Lake Erie basin, at least 80 percent of the phosphorus that is in the tributary system is in particulate, rather than dissolved form.

Conditions most conducive to soil erosion and phosphorus transport normally exist in the late winter and early spring. There is minimal ground cover on croplands then as a result of fall plowing. This is normally the period of heavy rainfall, which easily breaks up the exposed ground and moves soil particules. It is also the period when the ground is the wettest, a result of thaw and spring rains. This wet ground accelerates the processes that carry both the leached (dissolved) phosphorus and the particulate phosphorus to nearby drainage ditches.

Just as it is the rainstorms that introduce the particulate phosphorus to the Lake Erie drainage system, it is also those storms which play a major role in moving the phosphorus through the system to Lake Erie. When the creeks, streams, and rivers are at low flow, most of the sediment remains on the bottom, traveling little or not at all. When the tributaries are flowing fast as a result of rainstorms, the phosphorous-carrying sediment is suspended in the water and quickly moves downstream. Most point source phosphorous becomes attached to sediment and settled so both point and diffuse source phosphorous travels downstream as a result of this sediment suspension process.

Phosphorous loading in Lake Erie, as measured in 1974-75.

The journey from tributary headwaters to Lake Erie is a long one. The phosphorus entering far upstream first experiences several short trips as the small creeks rise and fall so quickly that the suspension process is over very quickly. Some phosphorus in the farm drainage ditches may never get started as the ditches are cleaned before a heavy enough flow occurs to suspend and move it. Once the phosphorus enters the larger rivers downstream however, it begins to travel very fast. The greater flow moves the phosphorus quickly. Of course, the phosphorus directly entering the larger river has a short, fast trip to the lake. Overall, the travel distance during rainstorms is great enough to move most material to the lake in about 5 years.

This storm-related travel has implications for the phosphorus load measurements which are being used to target Lake Erie phosphorus reduction. Since the 1-year measurement of phosphorus loading depends so greatly on that year's storm events, large variations may occur in these measurements from year to year. As phosphorus load reductions are achieved, careful monitoring will be necessary to insure that the reduction is not more weather-related than a result of improved practices.

Diffuse Source Investigations

The grand scale of the problem of diffuse source phosphorous loadings makes it difficult to even formulate a solution. First, the problem must be broken down and reduced to manageable sections. The Corps Study did this by developing a Land Resource Information System (LRIS) for the entire Lake Erie drainage basin. From 1976 to 1978, land-use and soil-type data were obtained and computerized for every use. The land-use information was obtained from high-level aerial photos provided by NASA, and, with the help of local counties and the U.S. Soil Conservation Service, information on local soil types was incorporated into the system. As a result information is readily available down to an area as small as 10 acres, the size of a medium field.

The erosion potential of this land can be calculated through use of the Universal Soil Loss Equation (USLE). The USLE provides an annual soil loss in tons per acre by multiplying factors concerning rainfall, soil erodibility, slope length, soil steepness, cropping, and erosion control practices. When we apply the USLE to the U.S. Lake Erie drainage basin, we find that the areas

most likely to suffer excessive erosion are found scattered throughout northwestern Ohio as well as the areas of Michigan and Indiana in the basin.

As stated earlier, crop-growing practices play a large role in the phosphorous transport process. The key, therefore, to solving the diffuse phosphorus problem must lie in an alternate crop-growing technique that contributes to erosion control. Of the elements involved in the typical crop-growing process, the tillage procedure is most directly involved in soil erosion. Because of its growth-inducing qualities, farmers cannot significantly reduce the amount of phosphorus which is applied to the land, but it appears that they can directly affect the amount that reaches Lake Erie by altering their tillage practices.

The conventional tillage procedure involves plowing a field so that the entire surface turf is overturned and planting is done on the resulting bare soil. We have seen how this contributed to the soil erosion process. Certain alternate tillage practices are sometimes practical and involve much less overturning of the soil. Practices generally classified as conservation tillage involve reducing the number of passes to increase the amount of residue. Most of the surface is left alone with its covering. That is, only the rows where the seeds will be dropped are plowed. An even more erosion-controlling tillage practice is that referred to as "no-till." In this case, planting is done directly in the residue of the previous year's crop. The planting is done with a planter which is specially equipped for planting in trashy, rough surfaces. Weed and turf control is achieved strictly with herbicides.

The erosion control provided by these reduced tillage practices is obvious. If less bare soil is exposed to the rain, less soil erosion will occur. This adoption, however, depends on the effect of crop yields. Farmers cannot afford to use these techniques when they decrease yield, despite the fact there is benefit in the decrease in lost topsoil. Fortunately, it has been shown that, under certain types of soil conditions, the reduced tillage practices can produce equal or better crop yields than conventional tillage methods. Even more fortunately, the soils on which these practices are feasible are generally the soils which have the highest erosion rates in the drainage basin.

Reduced tillage, in fact, appears to be the key to reaching the phosphorus reduction target. If reduced tillage were practiced in all the areas of the basin where it is economically feasible (as well as necessary for erosion control), the Corps estimates that the rural diffuse phosphorus loading will decrease between 4100 and 5100 metric tons a year. This will be sufficient to reach the total phosphorus reduction target, providing municipal point sources have been limited to the 1 milligram per liter (effluent phosphorus concentration) level. This statement also assumes that soil erosion reduction is 90 percent effective in reducing phosphorus transport. At present, the reduction in delivered phosphorus resulting from a given decrease in potential gross erosion can only be estimated and appears to be between 60 and 90 percent.

Reduced tillage is the conservation practice that can be broadly applied through many of the farms in the basin. There are however, several additional practices that, in particular instances, will help reduce the amount of sediment and phosphorus that enter the waterways. These include animal waste runoff and disposal systems and structural control of gully erosion. Subsurface

A "no-till" planter operates in the residue of the previous year's crop.

drainage systems allow better infiltration of rainwater and reduce sufficient phosphorus to achieve maximum production. In these cases, phosphorus application rates can be decreased, saving the farmer money and reducing the amount of phosphorus that eventually enters the lake.

These practices are currently being demonstrated in the Honey Creek Watershed, a 187 square-mile portion of the Sandusky River basin in northern Ohio that is generally representative of rural land in that region. The Corps, in cooperation with the local Soil and Water Conservation Districts, is gathering data on the phosphorus transport system in the basin and is assisting local farmers in the application of the various soil conservation practices, including reduced tillage, cover crops, and erosion control structures. The Honey Creek program, referred to as the Honey

Local farmers discuss "no-till" farming.

Creek Watershed Management Project, is intended to prove the effectiveness of these practices in controlling soil erosion while maintaining farm income. It is also intended to demonstrate to local farmers the benefits of these practices.

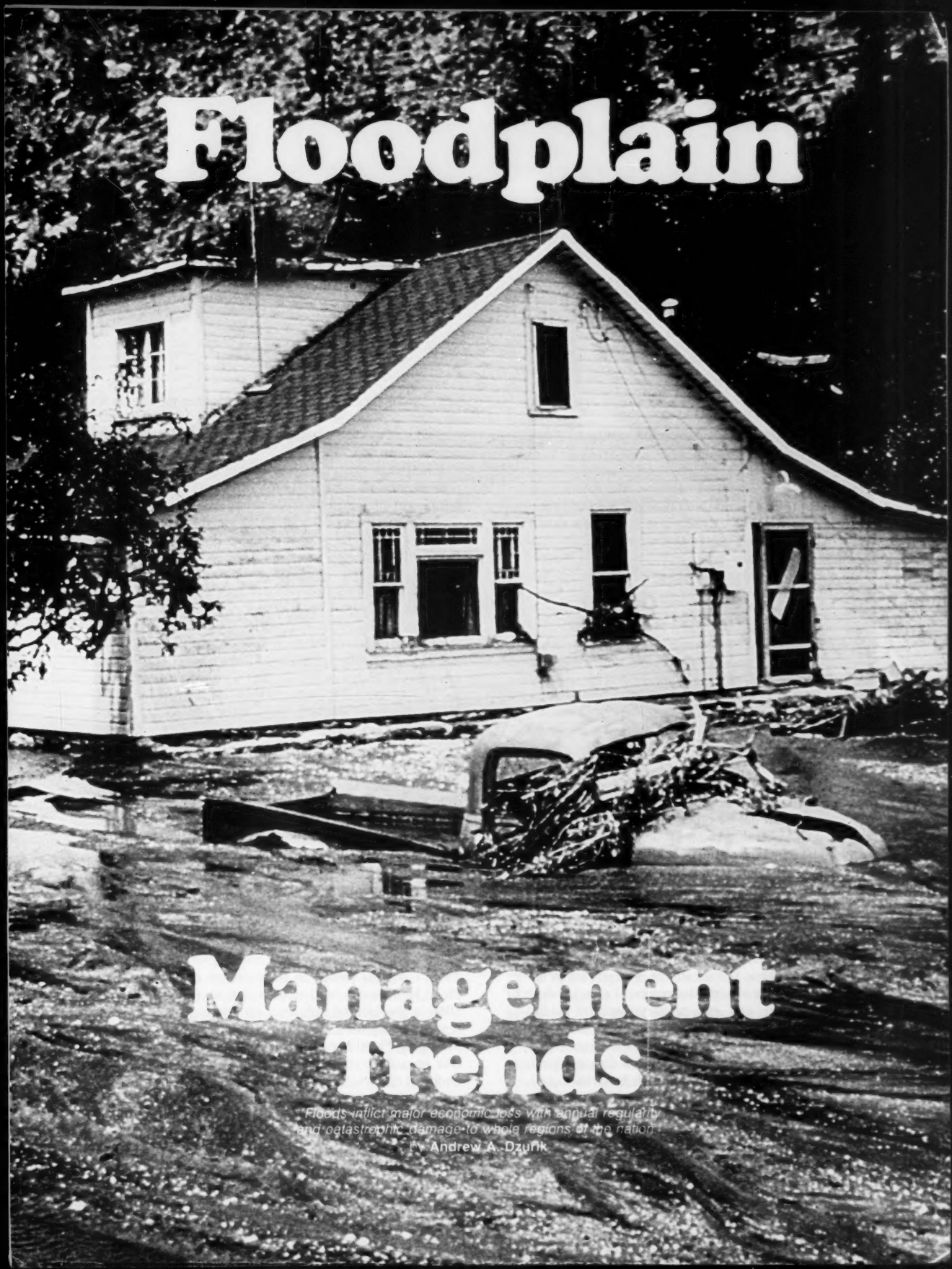
Spreading the Word

If reduced tillage is the answer to Lake Erie phosphorus problems, some way must be found to cause its adoption on the appropriate croplands in the Lake Erie basin. The idea is certainly a departure from conventional tilling practices, but it is not an entirely new idea. Some farmers have evidently been doing it since the 1940s. The current petroleum situation may also be an influencing factor as reduced tillage requires less trips over the land by farm equipment. Probably the best motivation, however, is the benefits the farmers will realize in terms of lost topsoil.

Despite these motivating factors, the local farmers must be informed of the benefits before they will decide to depart from their present tillage practices. The Corps hopes to provide this information through programs such as the Honey Creek Watershed Management Project. In addition, five other watersheds critical to the phosphorus reduction effort will be selected and model management programs will be developed. These watershed programs will demonstrate soil conservation practices on land forms and soil types that differ from those found in the Honey Creek basin. Aside from the individual basin studies, the Corps intends to implement a basin-wide education program to make local officials aware of the information it has developed. County Soil and Water Conservation Districts will be provided with data which reveals their county's contribution to the phosphorus loading to Lake Erie. They will also be provided with information concerning diffuse source pollution control and will be informed of the products available from the Land Resource Inventory Systems. Technical report presentations, seminars, demonstration events, field days, and local news media orientation will be used to spread the word.

So the prognosis for the "patient" known as Lake Erie is good. Her case is no longer reviewed as terminal, and a cure is available. The cure has cost millions of dollars in municipal treatment plant construction and operation and will require the adoption of the appropriate land management practices in the basin. But who is to say what the restoration of water, the substance necessary to life itself, is worth? Is it not a truly priceless commodity? Perhaps by the end of the eighties we will be able to remove from the sick-list a patient who had nearly been pronounced dead as the seventies began. ■

Corn grows from the residue of last year's crop.



Floodplain Management Trends

"Floods inflict major economic loss with annual regularity and catastrophic damage to whole regions of the nation."

By Andrew A. Dzurik

Floods inflict major economic loss with annual regularity and catastrophic damage to whole regions of the nation. Floods are unpredictable and are one of man's major concerns with respect to the natural environment. The relationship between man and the environment is reciprocal; sometimes man may modify the natural environment to suit his desires, but sometimes it is best to correct man, not nature.

In terms of the floods, one may either restrain the flood from overcoming man's constructions, or restrict man's activities in the face of flood hazards. Both alternatives must be considered in a program of floodplain management. Such broadly based considerations are becoming more evident in recent United States floodplain management policy, and the Corps of Engineers is playing a significant role in this advance.

Comprehensive floodplain management requires that the various modes of floodplain management be carefully coordinated and implemented systematically. The kind of planning necessary for proper floodplain management is done by some states and not by others and by some cities and counties and not by others, regardless of the impetus provided by Federal agencies. It appears that the intensity of political concerns about floods rises simultaneously with the flood waters but also recedes almost as precipitously. The states and municipalities have not been entirely remiss, however. The concern about floods is increasing at all levels of government, and the Corps of Engineers is in a position to both lead and follow changes in floodplain management techniques.

Flood control has historically been important to the Corps. Flood control activities represent a major share of the Corps' budget and are a primary source of public knowledge about the Corps. Although most floodplain management activities are associated with riverine flooding, a significant amount of flood damage results from coastal flooding associated with hurricanes, and, consequently, increasing attention is being placed on coastal hazards.

Initial steps toward a broader approach to floodplain management were begun in the early part of this century, but the revolution in the Federal role was the enactment of the Flood Control Act of 1936, which declared that there was a Federal responsibility in flood control. Both the Corps of Engineers and the Department of Agriculture shared responsibility under the Act. Not only did the Act address flood control, it was the first important Federal use of a benefit-cost ratio. One of the problems with this test for project approval has been the implied disincentive for local areas to use non-structural measures in floodplain management. The Federal government traditionally has paid a large part or all of the cost of structural control works, and none of the cost of non-structural controls. Thus, local governments saw unrealistic advantages in structural approaches.

The 1936 Flood Control Act was a bold advance in flood control, but it had significant limitations. The only method of solution to the problems of floods the Act contemplated was the use of physical structures to hold back or divert the onrush of high water. Floodplain managers now regularly use an array of approaches against the threat of flood damage which were not often used or commonly recognized in 1935. The Corps began its Floodplain Management Services Program in 1960.

The most recent thrust in floodplain management has come under the heading of flood insurance. As a prelude to the passage of the National Flood Insurance Act of 1968, Congress passed an authorization in 1956 for a Flood Insurance Administration, but never funded it. In 1966, a Presidential task force on floods produced a report, calling for a "Unified National Program for Managing Flood Loses," with specific recommendations. One immediate consequence of the report was Executive Order 11296 which required all Federal agencies to consider the flood hazard in their operations. A later consequence was the passage of the National Flood Insurance Act of 1968. The National Flood Insurance Program was revised in 1973 to expand the available

Dr. Dzurik is on the faculty of the Department of Urban and Regional Planning, Florida State University, Tallahassee 32306.

"A significant amount of flood damage results from coastal flooding associated with hurricanes."

limits of flood insurance coverage and to impose new requirements on property owners and communities. The 1977 amendments to this 1968 Act removed some of the restrictions regarding the provision of loans within flood hazard areas.

The increasing number of legislative actions encouraging or requiring regulatory management of floodplain uses is partly the result of increasing awareness of the legality of such regulations. The National Flood Insurance Act of 1968, as amended, requires that, for eligibility, communities impose land use controls that would have been nearly impossible thirty years ago, simply because the law that supports them was not well developed, and possibly because adequate public and political support was nonexistent. The original 1968 Act authorizing the Federal role in flood insurance granted Federally subsidized flood insurance for existing structures in those communities that participated in the National Flood Insurance Program.

No community was required to participate, nor were property owners in participating communities required to purchase flood insurance when available. The only incentive the original Act provided was that the subsidized insurance was available only for existing structures in communities whose floodplain management programs met the requirements of the Act.

The Flood Disaster Protection Act of 1973 subsequently revised the original Act by adding new incentives. The limits of subsidized coverage were doubled or more for categories of insurable property. Certain Federal funds and programs and Federal mortgage guarantees would be unavailable to those communities not participating in the National Flood Insurance Program. The impact of the 1973 Act has been mitigated somewhat by the Housing and Communities Act of 1977 which allows some funding to communities not participating in the Federal flood insurance program.

Other Federal laws also have sought to require consideration of flood hazards by communities. The Coastal Zone Management Act of 1972 facilitates the regulation of land in coastal areas in order to reduce the danger of coastal floods. This Act is a recognition and understanding of the natural and environmental system that exists in the coastal areas, and it was directed toward stimulating state and local involvement in the development of coastal resources management programs that were consistent with general Federal guidelines.

FEMA and Flood Insurance

A significant responsibility in floodplain management has evolved as a result of the National Flood Insurance Program and other emergency programs. The Federal Emergency Management Agency (FEMA) was created in 1979, bringing under its control a number of programs which were formerly in different Federal agencies.

Reorganization of Federal agencies dealing with emergency situations was proposed in June 1978. The Administration wanted to have just one agency responsible for emergency preparedness, mitigation, and response. In addition, a single contact point for state and local government agencies dealing with emergencies was desired. A third objective was to use the capabilities of peacetime emergency agencies and national defense agencies to complement and strengthen each other by working together. The new agency that was created as a result of this proposal became functional in late 1979 and now has consolidated all of the agencies and functions as intended.

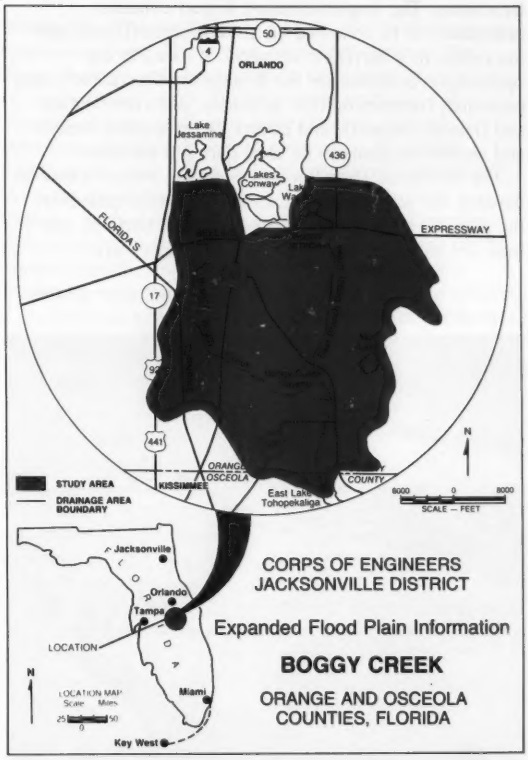
No function or area of responsibility of the Corps of Engineers was transferred to FEMA. The Corps' disaster response and recovery activities continue basically as they were before the reorganization. The Corps continues to do flood insurance studies for the Federal Insurance Administration (consolidated into FEMA from the Department of HUD.) Thus, FEMA is significant to the Corps and floodplain management in that it administers the National Flood Insurance Program. FEMA uses the Corps' technical capabilities to do flood insurance studies. These studies have created an opportunity for the Corps to improve its capabilities.

"Although wetlands preservation is one deliberate means of land use control, more general approaches are appropriate for floodplain management."

Expanded Floodplain Information Reports

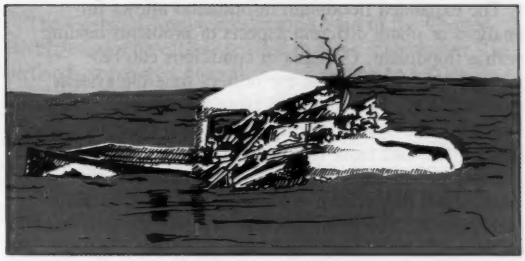
The Corps has a background of preparing floodplain information reports and flood insurance studies. These studies look at the existing conditions of a waterway. While this static view is a good starting point for planning purposes, it does not allow for future changes. Many areas are faced with growth that results in continuously changing land uses, which, in turn, alter the condition of the floodplain. One response to defining flood hazards in such areas has been to prepare a new type of study called an Expanded Floodplain Information Report, which looks not only at the present land use conditions in evaluating flood characteristics, but also at projected land uses. The reports evaluate the future effects due to the ever changing conditions of an area. The Corps also wanted to be able to provide a useful tool to local agencies dealing with floodplain management.

The Boggy Creek Study is an early example of an expanded report (Fig. 1). It looked at the hydrologic, economic, and environmental conditions that existed in 1976, and it projected future conditions. Boggy Creek Basin is primarily located in Orange County, Florida, the location of Disney World and the rapidly growing



Orlando urban area, and, with about 87 square miles of drainage area, forms part of the headwaters of the Kissimmee River. The Corps was concerned with three main issues:

- basic flood conditions (including flood flows, flood depth, and floodplain areas),
- flood damage potential (both single event and average annual floods), and,
- environmental conditions (habitat conversion and general resource management).



In order to keep the analysis techniques flexible and provide an ongoing planning tool, the Corps of Engineers Hydrologic Engineering Center has developed a system utilizing computer stored, gridded geographic data files, and programs to analyze this data. The data bank contains information on land use, topography, natural vegetation, soil classification, etc. The basin is divided into a gridded pattern and information about each 400′ x 500′ area is stored in a grid cell in the data bank. A number of utility computer programs can then analyze this data for flood hazards, economic damage, or environmental values. Once the data bank has been created, the utility programs allow for the desired flexibility in analysis. Different data variables or different management practices can be quickly evaluated through use of the data bank and thereby permit assessment of different aspects of the basin. As it is possible to update the information stored in the data bank, it is a valuable tool for continuing studies and for the local planner concerned with the area.

This system has retained the traditional methods and subject areas of floodplain information reports, but expanded both the methods and subject areas to include new ones. It not only looks at hydrologic flood hazards but also at flood damages and environmental information. The new methods employed include the automation of analysis and displays through use of the expanded floodplain information computer programs. This allows for analysis over a broad range of detail that was not easily done before (e.g., from analysis of the whole basin to analysis of a new subdivision).

The expanded floodplain information allows for analysis of many different aspects of problems dealing with a floodplain. Changes in conditions can be incorporated, although at the present time the system cannot quickly be changed if large areas have a change in land use. The system can handle gradual changes in the basin if the data bank is updated frequently, or fast changes in sub-basin areas. Once the data bank is established, this system is a useful tool for floodplain management. The main problem involves the data bank creation, which is both time consuming and expensive. In areas that will be able to update the data bank and have need for ongoing studies, this type of expanded floodplain information is worthwhile; for other areas, lacking the resources to do this, or areas not expecting rapid change, other methods may be more appropriate.

Emergency Evacuation Studies

Another evolving area of floodplain investigation by the Corps is the emergency evacuation study. This aspect of emergency preparedness is not only appropriate for coastal flooding and hurricane hazard areas, but also useful for certain riverine flood hazard situations.

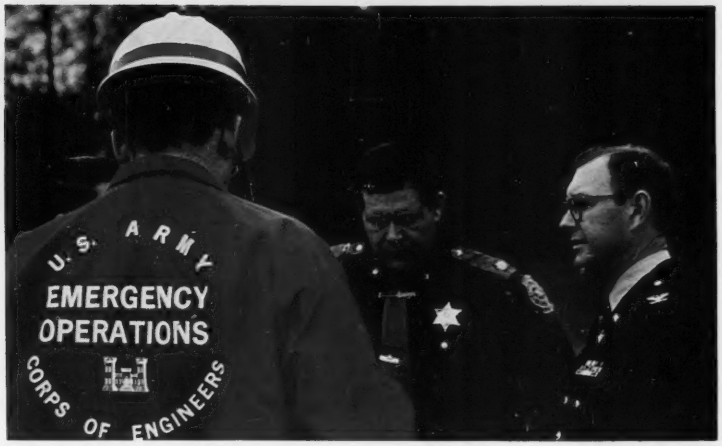
The Jacksonville District, Corps of Engineers and the Southwest Florida Regional Planning Council have produced a Flood Emergency Evacuation Plan for Lee County, one of the first such efforts by the Corps. The purpose of the plan is to prevent or reduce the number of deaths during a hurricane, and to address the response on a county and municipal level for the warning, evacuation, and shelter stages during a hurricane emergency.

Lee County has a total population of 184,000, of which 110,000 live in coastal areas with an elevation of 10 feet or less. Over 70 percent of the people living in the county have never experienced a major hurricane storm situation. The transportation system is located mostly in the low lying coastal areas or paralleling the Caloosahatchee River, and the roadway elevations are extremely low in the coastal areas. This combines for a high level of vulnerability to hurricane losses.

The plan has three main parts: Implementation Report, Technical Data Report, and Public Information Brochures. The Implementation Report contains procedures to be followed by government officials and the public in a hurricane situation. It contains the operating procedures for the Emergency Operation Center personnel (responsibilities, activities, and coordination and liaison contacts), and covers the evacuation routes and shelter locations to be used during a hurricane.

The Technical Data Report covers the methods used to develop the warning, evacuation, and shelter phases of the plan. In order to determine the route, shelters, and time needed for evacuation, several factors were

"Another evolving area of floodplain investigation by the Corps is the emergency evacuation study."



"An effective program of floodplain management can only occur by strengthening the Federal role."

considered. They include: 1) number of vehicles leaving evacuation zones, 2) number of persons utilizing Red Cross shelters, and 3) evacuation rates (vehicles per lane of roadway per hour). Traffic control problems and security of evacuated areas were covered. Special provisions were made for the evacuation of elderly, handicapped, and others lacking private transportation. Also the capacity, quality and location of primary shelters, secondary shelters, and refuges was determined. Communication and coordination procedures between the shelters and the emergency operation center are also outlined.

A series of brochures has been prepared for public distribution. The first one covers hurricane preparedness—the courses of action to be followed in a hurricane situation; how to stay informed, preseason preparedness, evacuation procedures, and shelter locations for particular zones.

This plan is the first coastal county evacuation plan that the Corps has developed at this level of detail. The Corps has worked on several evacuation plans for inland communities for river flooding, but this plan for Lee County, and the plan for the Tampa Bay Region, just now starting, are new activities for the Corps.

The Tampa Bay Region Study will use the Lee County Plan as a model. It is a much larger scale project (dealing with a population of 1.6 million rather than 184,000), and is scheduled to take 20 months (to be finished in July 1981.)

Other Approaches

Wetlands preservation has become a growing issue nationally, particularly in terms of conservation and environmental protection. Interest in wetlands has been traditionally concerned with preservation of habitats for migratory waterfowl, but the interest is expanding to recognize broader values of wetlands. The Corps has been directly involved through the Dredge or Fill Permitting Program under Section 404 of the 1972 Amendment to the Federal Water Pollution Control Act. It also recognizes the value of wetlands as a floodplain management device.

The Corps of Engineers demonstrated in the Charles River, Massachusetts watershed that the mainstream wetlands serve as a natural storage system to reduce downstream flood crests (See *Water Spectrum, Vol. 10, No. 3, Summer 1978.*) The Corps built a structure in the lower portion of the Charles River to replace a dam built in 1910 that formed the Charles River Basin and eliminated extensive mud flats by maintaining a stable water level in the Basin. It also protected low areas from high tides and tidal flooding, created valuable real estate along the Basin's shoreline, and an important public recreation area for Boston. Because of extensive urban development, flooding had become a severe problem in the areas. The new dam will help to alleviate flooding, but the design was done in conjunction with a deliberate upstream program of wetlands preservation for flood storage—the first such effort by the Corps of Engineers. Over 20,000 acres of wetlands had done the job of retaining and gradually releasing flood waters. Extremely wet weather conditions have already demonstrated that this structural/non-structural approach works effectively—with the wetlands storing flood waters, and then gradually releasing them for retention and release in the Basin.

Although wetlands preservation is one deliberate means of land use control, more general approaches are appropriate for floodplain management. Land use controls are a major element in programs of floodplain management. The Corps has become increasingly active in land use related programs and will likely become more so in the future in all areas of planning for water and related land resources. Regulating the activities that take place on the floodplain can maximize economic efficiency and productive use while minimizing the hazards of property damage and loss of human life. There are many legal issues involved, but regulation of land in facing the hazard of inundation is based on well-founded legal principles.

Numerous powers are available to the states and local governments to exercise land use controls. Included are zoning, subdivision regulations, and planning. Other

powers which they have available are eminent domain, easements, and use-value assessment taxation. These powers have existed for years, but in most instances state and local governments have been hesitant to use them for floodplain management.

The Corps of Engineers had been involved, less directly than indirectly, in land use management in all of its civilian projects. Communities have long had the power to institute comprehensive floodplain regulations, but has the Corps the authority to require that communities adopt a program of floodplain management if they wish to receive the benefits of a Corps project? It seems that the Corps has the general authority to do so, and has had it for a long time, but, traditionally, it has been reluctant to take an overt part in local regulation.

Perhaps one of the strongest statements regarding the potential Corps' involvement in land management is contained in the Report of the Task Force on Civil Works Planning (*U.S. Department of the Army, 1971*). In terms of floodplain management services, the report stated that all reasonable means should be considered for achieving sound use of floodplain land. Further, the field offices of the Corps should intensify efforts to foster state and local adoption of regulations over unwise floodplain uses, for "... potential benefits to the Nation for this relatively economical effort are probably greater than in any other aspect of the civil works planning program." The report makes additional statements regarding the Corps' potential involvement in land use planning, including "... waterfront renewal ... and land-use planning generally. *(Ed.'s note: The report referred to was an advisory report prepared by consultants hired by the Corps. The reader should not infer that the statements are of Corps' origin or were even adopted by the Corps.)*

The results of a recent study *(Dzurik, 1976)* help to explain the unwillingness of the Corps to intervene in "local" matters regarding land use. As part of the study it was found that there is ample state and local authority for land use controls in the floodplain. The real question is whether or not state and local governments choose to use their authority, or rely primarily on the Federal government, in particular the Corps of Engineers, to deal with flood damages. Central to the study was a survey of the Corps' own view of its role. One of the clear findings is that the Corps is very aware of the alternatives available in responding to the dangers of floods. The Corps cannot be pictured as being ignorant of the possibilities nor of their respective advantages. Most district engineers and planning chiefs stated that the land use implications of projects must be squarely faced.

Summary and Implications

Floodplain management has gone through an evolutionary process in this country, but increasing urbanization and more intensive use of floodplains have resulted in substantial increases in annual damages. The Federal government has responded with the National Flood Insurance Program. Organizationally, the FEMA has been created to consolidate a number of Federal agencies dealing with emergency situations. Emergency evacuation studies have been started under the auspices of the Corps of Engineers to deal with one aspect of hurricane hazards. Other programs, involving all levels of government, are being tried to deal with one aspect of hurricane hazards. Still other government programs are dealing with wetlands and land use controls.

An effective program of floodplain management can only occur by strengthening the Federal role. Many of the needed tools exist, but the Corps of Engineers, as the lead agency in floodplain management, must continue to take a more active and aggressive role in working toward reduction of flood damages. The Corps can strengthen its role by more strongly developing its image as an environmentally conscious Federal agency, and continuing to emphasize non-structural alternatives for floodplain management. Through recent use of a more realistic discount rate, the Corps has diminished its "pork-barrel" image and should continue to do so by utilizing more objective cost-benefit analyses as part of its planning process. ■

Water Weed Uses

by **N.W. Pirie**

Mr. Pirie was head of the Biochemistry Department, Rothamsted Experimental Station, Harpenden, United Kingdom.

*The Common Cattail and Bulrush (*Typha latifolia *and* Scirpus*). These tall, perennial, marginal aquatic grasses are common throughout the U.S.* (Photos by Dr. C.E. Boyd of Auburn University, unless otherwise noted.)

Weeds are pulled up or poisoned unremittingly by farmers and gardeners. Ecologists and hikers are more tolerant, they like the appearance of some weeds and cherish others because of the butterflies they harbour. Few people would like to see all plant growth cleared from a piece of land so that it could be kept permanently bare. Similarly, though seldom actively encouraged, seaweeds are not the victims of eradication campaigns. The situation is very different on areas of fresh water. Growth is tolerated on lily-ponds and a few such areas, but the ideal state, in the opinion of many users of fresh water, is the almost complete absence of visible plant life. Plants that discretely stay permanently underwater are not so generally disliked. This is partly because their value as fish-food is recognized, and partly because, even if they were disliked, it would be difficult to make the dislike effective.

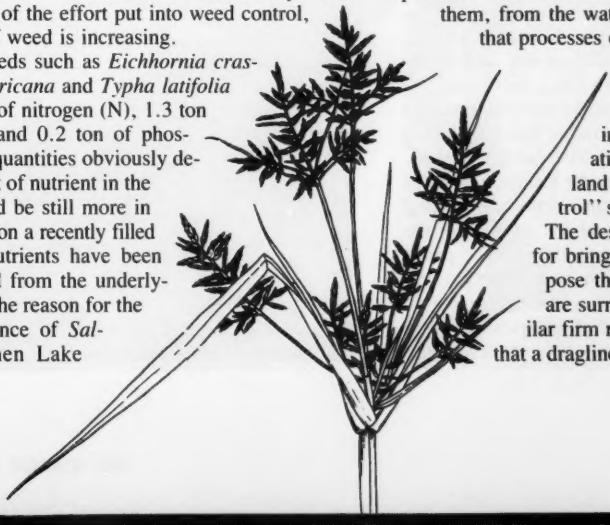
Some hostility towards emergent weeds is understandable. They obstruct the passage of ships, and the flow of water in irrigation channels. They may increase the annual loss of water by evaporation by as much as 2.3 m. In this respect there are great differences between species: in one survey, *Pistia* and *Ipomoea aquatica* had little effect whereas *Cyperus rotundus* more than doubled the rate of evaporation. They may harbour disease vectors. Thus, only 5 percent of schoolchildren in villages that became coastal when Lake Volta was filled had schistosomiasis before the filling, but 90 percent were infected soon afterwards because the snail vector lived in the water weed. Dead weeds, when they rot, discolour and taint drinking water.

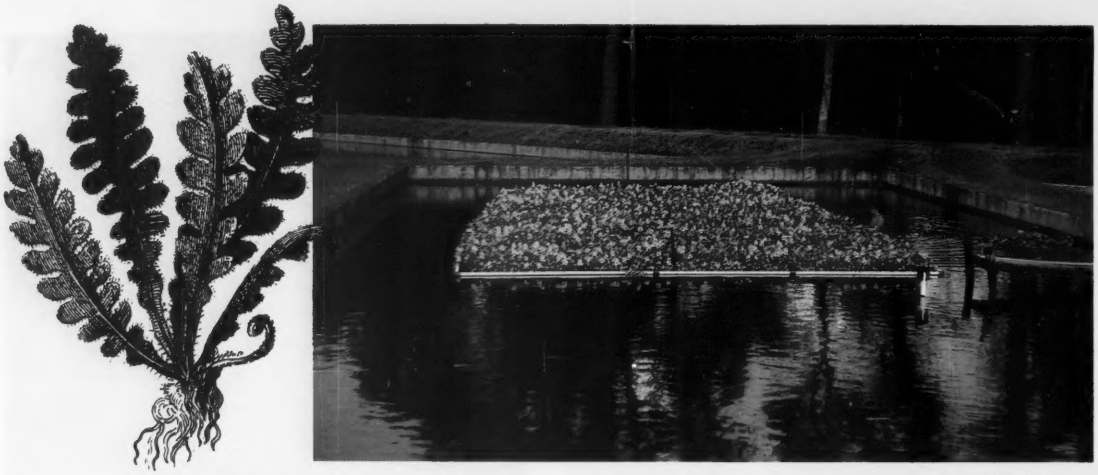
This may not be a health hazard, but many consumers find these things unaesthetic. Similarly, opinions vary about the appearance of emergent weeds. Many people find reeds fringing a lake or river attractive, and like to see a pond with a smooth, continuous covering of *Lenna*, others do not. For all these reasons, intensive campaigns are mounted to kill water weeds. There are no precise estimates of their cost worldwide, although it is somewhere in the region of a thousand million dollars a year—probably more. Weeds are battered to death with flails, cut and removed or allowed to float downstream, starved to death by changing the water level, attacked by deliberately introduced pests, and poisoned with a range of herbicides. The relevant journals contain many laments at the inefficiency of these methods. Furthermore, as waterborne sewage is increasingly used, and as fertilisers are increasingly put on to farmland near waterways, weed growth is stimulated. Several surveys conclude that, in spite of the effort put into weed control, the total amount of weed is increasing.

A hectare of weeds such as *Eichhornia crassipes*, *Justicia americana* and *Typha latifolia* may contain 1 ton of nitrogen (N), 1.3 ton of potassium (K) and 0.2 ton of phosphorus (P). These quantities obviously depend on the amount of nutrient in the water. There would be still more in the copious growth on a recently filled reservoir before nutrients have been completely leached from the underlying soil. This was the reason for the temporary exuberance of *Salvinia molesta* when Lake Kariba was filled. When continuous flow is established, water to which sewage disposal and other human activities are adding little NPK may support less weed growth. Thus the *Pistia Stratiotes* on Lake Volta contains only 84 kg of N ha^{-1}, but three times the amount of K. The extent to which weeds remove nutrients from water has been studied in a few experiments; sewage effluent which originally contained 1.4 mg of P l^{-1}, contained only 0.2 after *Eichhornia* had grown in it for five weeks. These quantities of NPK, released from killed weed that is simply left to rot where it grew, would encourage further weed growth unless the weeds had been killed with herbicides. But in that case, residual herbicide may give the water an uncertain value for irrigation. The only argument for leaving battered leaf in the water in which it grew depends on the claim that herbivorous fish eat the weed more readily after it has been crushed, and that any form of mechanical control brings emergent leaves down within reach of fish. This undoubtedly makes some use of the weed, but most of the nutrients in it reappear in the fish excreta. Similarly, weed control by ducks, swans or manatees is only a partial remedy for eutrophication. Eutrophication is more completely cured by processes which remove weeds, or products made from them, from the water for use on land. It is surprising that processes of this type get so little attention in textbooks and symposia dealing with the control of water weeds.

Collecting weed, especially floating weed, on a body of water is relatively easy: moving it from water to land is more difficult. That is why "control" so often means no more than cutting. The design of some equipment suggested for bringing weed to land seems to presuppose that all the relevant pieces of water are surrounded by a tow-path or some similar firm roadway, or that they are so narrow that a dragline on the bank could manage the job.

*The American Lotus (*Nelumbo lutea*). A rooted, perennial, floating aquatic plant which features large, branched rootstocks.*





*The Water Hyacinth (*Eichhornia crassipes*). This aquatic herb forms floating masses which clog freshwater bodies in the southern U.S.*

These may be the conditions in irrigation ditches. In more open bodies of water it would be preferable to mount whatever equipment is used, for at least the first stages of processing, on a barge associated with the unit used for harvesting. Material would then be off-loaded at a properly equipped pier. Even when weed is going to be used as compost on land near the water from which it came, conditions will seldom allow it to be swung directly to the place where it will be used.

The amounts of material that would have to be handled are formidable. During the more productive parts of the year, *Eichhornia* and the reeds *Typha* and *Phragmites* can accumulate 30 to 60g of dry matter $m^{-2}d^{-1}$, i.e. a daily increment of 0.3 to 0.6t per ha. Freshly harvested weed contains 90 to 95 percent water. Therefore, during parts of the year, 5 to 10t of fresh material could be harvested daily from one hectare. Fresh weight figures up to 470t ha^{-1} are quoted for the weight of the mature standing crop. Similar figures are quoted for *Cyperus papyrus*. Those for most other weeds are a little less impressive. Nevertheless, it is clear that quite a small body of water could keep a collecting unit and off-loading point busy throughout the growing season. This is usually regarded as an embarrassment with a water weed—a similar yield from a forage plant on land would be welcomed.

The comparison with forage is not unrealistic: many weeds resemble medium grades of forage in composition. Some representative N analyses are given in the table. As with conventional forages, the actual value on any sample depends on the stage of growth at which it was harvested, and on the extent to which the method used for harvesting selects leaf, which is usually rich in protein, rather than stem which is poor. Several amino acid analyses have been published. There are such discrepancies between the results, especially for mathionine, that it does not seem worthwhile quoting any of them. Carefully conducted analyses on some of the more abundant water weeds are urgently needed, partly because the results will affect the amount of effort put into finding nutritional uses for weeds, and partly for purely scientific reasons. The trustworthy leaf analyses that have been published so far show only small differences between species. Water weeds belong to several hitherto unstudied families—including the ferns. It would be interesting to know how widely the uniformity of composition extends.

Animals can be seen voluntarily eating water weeds in many parts of the world. There is no reason to think that any mammals prefer water weeds to the more familiar grasses, herbs and bushes, but it is obvious, in spite of many statements to the contrary, that weeds can be eaten. More research is needed to find how much the animals gain from

THE NITROGEN CONTENT OF SOME WATER WEEDS

Species	Popular Name	Percentage of Nitrogen in the Dry Matter
Allmania nodiflora	Paddy weed	4.9
Alternanthera philoxeroides	Alligator weed	1.3-3.5
Ceratophyllum demersum	Coontail	2.7-3.0
Cyperus digitatus	Sedge	1.2-2.1
Eichhornia crassipes	Water hyacinth	1.3-3.7
Eichhornia crassipes	leaves only	5.0
Elodea conadensis	Canadian pondweed	2.2-6.3
Hydrilla verticillata	Hydrilla	2.7
Ipomoea reptans	Water bind-weed	4.6-5.8
Justicia americana	Water willow	1.6-3.8
Lemna minor	Duck weed	2.5-5.0
Myriophyllum spicatum	Milfoil	1.8-4.1
Phragmites communis	Reed	1.8
Pistia stratiotes	Water lettuce	1.7-3.9
Polygonum hydropiper	Knot weed	3.2
Potomogeton sp.	Pondweed	1.1-3.5
Salvinia auriculata	Salvinia	0.8-1.8
Typha sp.	Reed-mace	0.5-2.4

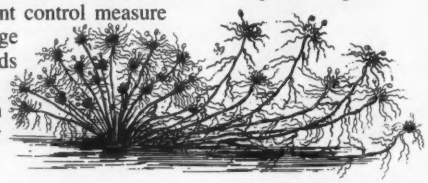
A prototype leaf juice extractor. The paddles rub the leaf before pushing the mass into the mechanism at right where it is pressed. Inset is the cone assembly that presses the pulped leaves. Note the light construction that is adequate for the job. (Photo by the author)

eating them. The present situation has its comic aspects. In China and Singapore, although *Eichhornia* has not been long established there, it is deliberately cultivated for use as pig food. In Vietnam it does not seem to be encouraged, but the natural growth is harvested for pigs. After many years when attempted eradication was the only attention given to it in India, a little is now being used as cattle feed. In spite of this practical experience, expert opinion has until recently rejected the idea of using *Eichhornia* as fodder. This comes about partly for the familiar reason that a new idea, or an old idea in a new context, takes time to be absorbed, and partly for some extraordinary reasons. For example: a recent review of the situation in Florida argued against using *Eichhornia* as cattle feed because the number of cattle now kept there would be able to eat only 2.25 percent of the available weed. That is to say, *Eichhornia* was being thought of purely as a problem and not as a resource. To be advantageous, it is not necessary that a use should be total.

This boat wake cuts through a heavy covering of Salvinia on Africa's Lake Kariba, shortly after the lake was filled. (Photo by the author)

Less attention has been paid to other weeds. In China *Alternanthera* and *Pistia* are given to pigs and rabbits; in East Africa, cattle thrive on *Cyperus digitatus*, and in U.S.A. chicks did well on *Cladophora, Potamogeton, Myriophyllum, Vallisneria* and *Lemna* after a period of acclimatisations. *Lemna*, well known as food for ducks and fish, is also widely used as cattle feed; its tiny relative, *Nolffia* is used as human food in South East Asia. Attempts to use *Salvinia* as cattle feed in Indonesia were unsuccessful.

In regions where weed is abundant throughout the year, the suggestion that silage should be made seems, at first sight, surprising: silage-making is thought of as a means of conservation, and that would be unnecessary. Palatable *Eichhornia* silage was made twenty-six years ago and extensive use of it in the Sudan was advocated twelve years ago, but it is still little used, and harvesting for silage is not an important control measure anywhere. Silage made from weeds is often more acceptable than fresh weeds for several reasons. It contains less water, and the juice that flows away during the fermentation carries with it some of the unattractive, or unfamiliar, flavors and replaces them with the flavors of the fermenting microorganisms. Acids are produced during the fermentation and these dissolve calcium oxalate crystals which, in many weeds, are thought to irritate animals' mouths. It seems likely that one reason for failure with some batches of silage is that too little acid was formed. For obscure reasons, the ash content tends to be greater, and the fermentable sugar content less, in weeds than in the familiar forage plants. Weed silage is therefore more strongly buffered and becomes less acid than forage silage. Before silage from any species of weed is dismissed as unpalatable, attempts should be made to improve its quality by adding acid (as in AIV silage) or molasses. So far no one seems to have made a weed silage that is as palatable as forage silage. The descriptions of these trials usually do not state clearly that the cattle were given weed silage for a period sufficiently long to allow the necessary changes in taste preferences and rumen flora to be established. Several weeks may be needed for such acclimatisation.

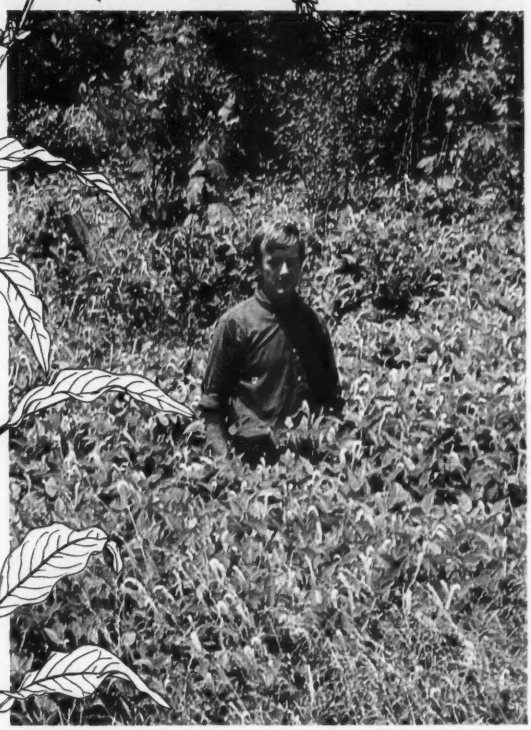


Predators control water weeds in their countries of origin, artificial control is needed when they are taken elsewhere by accident or folly. (*Eichhornia* was being sold as a decorative plant in Cairo in 1958!) The need for control also arises because the more prolific weeds tend to be the less palatable ones. Palatability can be increased by altering the texture of the weed and by removing much of the flavor and the mineral salts. Weeds have a tendency to contain more mineral matter than is desirable in ruminant fodder. Some of these improvements are brought about more effectively by drying than by ensiling. Consequently, dried *Eichhornia* is a satisfactory substitute for part of the normal diet of chicks and laying hens. Because of the abundance of carotenoids in it, it improves the color of the yolks. Sheep and goats grew normally when 35 percent of their diets were dried mixed weeds from North American lakes. Such results are encouraging—but not strictly relevant. It would be uneconomic to dry such wet material.

Many claims have been made for processes by which moisture is *pressed out of* weeds. The phrase is misleading. Surface water can be pressed *off* weeds. To get moisture *out*, leafy material must first be extensively damaged by cooking or, preferably, rubbing. The objective is to rub thoroughly without breaking up leaf fibre so completely that the pulp becomes intractable. Various types of screw expeller, preceded by some form of disintegration, were used in most of the recent trials. Figures for power consumption during de-watering need not be quoted because friction in a conventional screw expeller, working on unlubricated material, wastes a great deal of energy. Assessments of power consumption and costs involved in processing weeds must wait until there has been much more work on the design of sensible equipment for this particular job.

By pressing heavily it is possible to make from leaves fibrous press-cakes containing only 60 percent of water. It is probably better to be satisfied with gently pressing and a cake containing 75 percent of water, although twice as much water has to be evaporated from the latter to get the

*The Spatterdock (*Nuphar advena*). A common, floating perennial.*



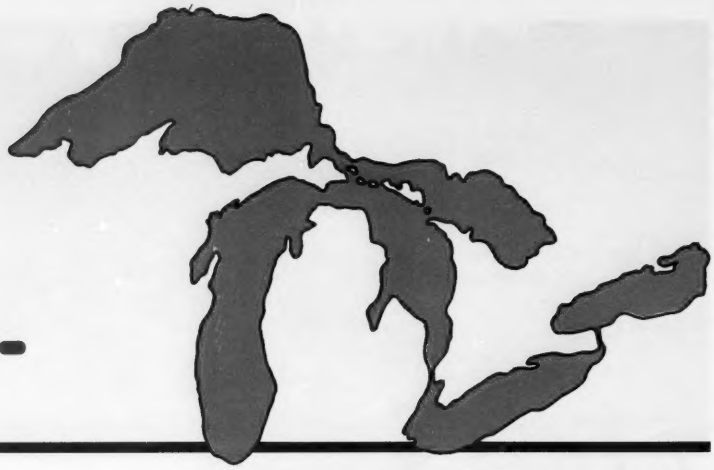
*The Lizard's Tail (*Saururus cernuus*). Currently confined to southeastern states, this tall plant forms from slender rootstocks. It has white, heart-shaped leaves.*

same amount of dry matter. However, in many circumstances, the press-cake would not have to be dried artifically. In a dry climate, material containing 75 percent of water will dry in air; in any climate, good silage can be made from it if molasses is added. For the heavy pressing needed to get drier material, a press of the "hornangle" type should be used. In this, in contrast to the situation in a screw expeller, there is no relative movement between the fibre and the metal of the machine.

Water weed that has been fractionated in that manner should be more palatable, but it may be less nutritious because the juice pressed out carries with it part of the protein and much of the digestible carbohydrate. Leaf protein that can be used as human or animal food has, during the past 30 to 40 years, been made from similar extracts from fodder crops by coagulation, filtration and pressing. Commercial production has started in several countries. For obscure reasons, protein does not seem to extract as readily from floating weeds as from most land plants. Nevertheless, a protein concentrate is being made commercially in the Philippines from *Eichhornia*. Extraction tends to be more satisfactory from emergent rooted weeds such as *Justicia americana*.

Ideally, all the products made by processing weeds would be used as food or fodder. Composting gives a smaller return because, in a hot country, only a fifth or a tenth of the N in composted material is recovered in the next crop. Methane fermentation conserves the NPK in weeds but, even after the recent increases in the cost of fossil fuels, food and fodder still cost more. The equipment used to make partly dried cattle fodder should be on a barge so that only the compact product has to be off-loaded in the evening. Equipment for making leaf protein could also be on the barge. Alternatively, the juice could be stored: pumping it ashore would be much easier than hoisting unprocessed weed ashore. It may, however, be more practical to use the juice as irrigation water, or even to discard it. That would waste protein, and would be much less effective as a means of abating eutrophication. The juice from most water weeds is so dilute that coagulating it would be expensive, and, with all types of leaf, the residue from which part of the protein has been extracted is probably the most valuable product of fractionation. Choice between the possible systems will depend on local circumstances and on the results of research. There has been very little relevant research so far. If 0.1 percent of the money now spent on doubtfully successful attempts to eradicate weeds were spent on finding uses for them, a problem would become an asset. ■

Events, Deeds & Deliberations



Ecosystem Approach Needed to Clean Up Lakes

The waters of the Great Lakes are troubled and their problems won't be solved on a piecemeal basis. All water resource problems must be examined for their effects on the entire Great Lakes system, says Lee Botts, chairman of the Great Lakes Basin Commission.

"To establish clean water policies," Botts said, "we must consider the Great Lakes and their connecting waterways as one large system. Therefore, we need to develop standards which deal with the lakes' complete ecological system."

Botts said the two major problems in the Great Lakes Basin are eutrophication and the presence of toxic substances. Eutrophication, the natural process of lake aging, was accelerated by accumulations of phosphorus which were discharged into the lakes through city sewage, industrial waste and runoff. This caused the nutrient levels to be higher than normal. Algae blooms, triggered by the phosphorus, consumed large amounts of oxygen.

In 1972, the United States and Canada signed an agreement to reduce the levels of phosphates discharged into the lakes, particularly around Detroit.

According to Botts, the phosphate detergent ban was responsible for dramatic decreases in the amount of phosphates in both the Great Lakes and the smaller inland lakes. Over time, she expects the decreases will become even more evident.

The problem of toxic substances was not recognized until after the 1972 agreement, when scientists first found it was possible for chemicals such as DDT to get into the food chain and accumulate in living creatures. Then, following the ban of DDT and the subsequent reduction of the chemical in the lakes, rising levels of PCB were discovered. This problem was much more complex because of the widespread use of PCB and the great effort it took to get the attention of the Federal government, according to Botts.

She said it was only when high levels of the contaminant were found in the Hudson River that the Federal government realized the chemical posed potential problems for all water systems and began to take action.

"In 1972, the emphasis was on stopping what came out at the end of the pipes from being discharged into the lakes," Botts said. "We now know that a large part of the pollution is getting to the lakes through the air in the form of acid rain, or sulphur dioxide, caused by the burning of organic fuels."

As scientists continue to look at the entire ecological picture, they now believe that removing the hardwood forest along the Great Lakes caused great changes in vegetation in the lakes. In addition, the small temperature changes in rivers resulting from the loss of forest cover is believed to have allowed the entry of the sea lamprey into the lakes.

Botts said it is unrealistic to think that the Great Lakes can be restored to the way they were before man concentrated himself in the area, but they can be preserved and improved for a variety of purposes.

She stressed the need to apply what we have learned to future problems before they get out of control and urged people to recognize the problems of toxic wastes and find ways to deal with them.

The Great Lakes Basin Commission is attempting to get all states within the basin to work together and establish policies to deal with the waste problem. One idea it is proposing is a system to keep track of a potentially harmful substance as it is moved from one location to another via the lakes. The shipping paper on each substance would include information on how to deal with accidental spills.

"A major problem has been that local police and firemen who are often called on to deal with these problems don't know what to do," Botts said.

She said there is an urgent need for education about wastes and ways in which they can be recovered and restored as much as possible.

"The wastes have to be managed—they won't just disappear because people say they don't want them," she warned. "If people continue to run away from the problem, illegal methods of disposal will continue and will possibly grow worse." ■

Sand Dunes Topic of Controversy

The spectacular sand dunes that line western Michigan's coast and provide recreational activities for many vacationers have become the subject of dispute between industry and environmental interests.

Foundaries use the dune sand to make molds for castings of such things as machine parts. Environmentalists and various citizen groups argue that there are many offshore and inland sources of sand which the foundaries could use for the same purpose. They believe that the higher cost of transporting the inland sand and the inaccessibility of offshore sand are the real reasons the dunes are mined.

"The removal of sand dunes affects more than the initial site," says Eckhart Dersch, Michigan State University Cooperative Extension Service watershed management specialist and professor of resource development. "The activity can affect water resources, recreation, property values, agriculture and vegetation in the entire region."

The Sand Dune Protection and Management Act, passed in 1976, requires mining companies to apply to the Michigan Department of Natural Resources for permits to mine. Companies are also responsible for providing an environmental impact statement describing the likely impact of mining on the area.

Citizens' groups such as Hope for the Dunes and the Lake Michigan Federation are concerned because the Department of Natural Resources has not yet established strict guidelines for preparing the environmental impact statements.

A search of national and international information and resource people was carried out and the results assembled into a matrix to show areas where mining activities would have a direct impact on the environment.

"We wanted to describe how to quantify the impacts, but the information was not available and the time was limited," Dersch explains. "We could not describe in a universally applicable equation the impact that sand removal would have on agriculture, for example. These effects are very dependent on the configuration of each dune, the direction and velocity of winds, and vegetative characteristics.

Though the sand dune protection law went into effect in 1978, no permits to mine were denied until August 1979. Then an application to mine an area near Grand Mere was denied because of the uniqueness and vulnerability of the dune area. Another permit to mine a site near Bridgman was denied in October for similar reasons.

An amendment to the dunes protection act, House Bill 4875, would make the situation even more complicated. Opponents believe that the bill, which is still in committee, is very dangerous because it would remove most of the state's dunes from protection or management.

Other states have found ways to preserve their dunes. Dersch points to Massachusetts, where many of the dunes were made into public parks, and to New Jersey, which prohibited even foot traffic on the dunes when it was discovered how fragile they are.

"The wildlife and vegetation on sand dunes are precarious at best," Dersch stated. "They are susceptible to high lake levels and erosion, as well as changes in wind direction and temperature. Removal of vegetation from the dunes can start a blowout. As the sand moves slowly inland, it may cover up homes, trees and entire forests." ■

1979 Design and Environmental Awards Announced

Winners of the 1979 United States Army Chief of Engineers Design and Environmental Awards competition have been announced in Washington, D.C.

Twenty-three Army Corps of Engineers projects were selected by juries of distinguished professionals to receive awards. The highest award winners were recognized at an awards banquet sponsored by the National Society of Professional Engineers as part of National Engineers Week.

Recently completed civil works and military construction projects were eligible for entry in four competition categories: architecture, engineering, landscape architecture and environmental. Entries judged worthy of national recognition received one of three awards: Honor Award, Award of Merit or Honorable Mention. There were 83 Corps of Engineers projects worldwide entered in the 1979 competition.

The recipients of the Honor Award were U.S. Army Engineer District, Sacramento (architecture and environmental), and U.S. Army Engineer District, Seattle (landscape architecture). No Honor Award was made in the engineering category.

The Chief of Engineers Design and Environmental Awards program was begun in 1965 to recognize excellence in design and environmental achievement related to structures completed or areas developed by the Corps of Engineers and their consulting firms. It also serves as the U.S. Army's support to the Federal Design Improvement Program. ■

Two Foreign Crocodile Species Listed as Endangered; Three-Fourths Now Protected

Two more crocodilians—the Saltwater and American—have been brought under the protection of the U.S. Endangered Species Act, ending further commercial trade in this country in the products made from their hides such as shoes, boots, purses, briefcases, and other personal and household items.

The saltwater crocodile is one of the world's largest reptiles, growing longer than 20 feet and weighing several hundred pounds. It ranges in coastal waters

throughout Southeast Asia; including Australia, Papua New Guinea, Indonesia, the Philippines, Malaysia, Thailand, Burma, Bangladesh, India, Cambodia, Vietnam, and Sri Lanka. The saltwater crocodile population in Papua New Guinea was excluded from the listing because of the strict protection it is given in that country.

The Florida population of the American crocodile, which ranges from South Florida to the Keys, was listed as endangered in September 1975. The remaining populations of this species are found throughout the Caribbean Sea, and on the Pacific Coast of Central and South America from Mexico to Ecuador. ■

Bookshelf

Principles of Water Quality Management, by W. Wesley Eckenfelder, Jr., develops technologies for treatment of industrial wastewaters and provides numerous examples of application. It also covers municipal wastewaters. In this 727-page casebound book, the author covers such subjects as treatment processes, sludge handling, land and deep well disposal, wastewater characteristics, oxygenation, and economics. Available for $24.95 from CBI Publishing Co. Inc., 51 Sleeper St., Boston, MA 02210.

History of Federal Water Resources Programs and Policies, 1961-1970, by Beatrice H. Holms, covers that period in which water pollution control became the most important Federal concern in water resources planning. It serves as a companion piece to her earlier work which reviewed the first 160 years of involvement. Available from the Superintendent of Documents, U.S.G.P.O., Washington, D.C., 20402, as Stock Number 001-000-04059-6.

Opportunities and Uses of the Ocean, by David A. Ross, explores the present and future potential of the world's oceans. It focuses on problems that can be solved by applying current scientific and technological capabilities. The author discusses the legal aspects of ocean use, marine shipping, military usage, and coastal zone divisions. This 320-page illustrated book can be purchased for $19.80 from Springer-Verlag New York Inc., 44 Hartz Way, Secaucus, NJ 07094.

Environmental Atlas of the Potomac Estuary, by A.J. Lippson, et al is a comprehensive volume that gathers together most of the published and much of the previously unpublished material pertaining to the portion of the Potomac under the influence of the tides. The physical, chemical, and biological aspects of the environment are depicted by over 100 full-color maps. Copies may be purchased for $19.00 from Dr. Randy Roig, Power Plant Siting Program, Maryland Department of Natural Resources, Tawes State Office Building, Annapolis, MD 21401.

Annual Report of Marine Mammals, by the Fish and Wildlife Service, is an illustrated report that highlights the Service's efforts to protect the endangered West Indian and West African manatees and the threatened California population of sea otters. Copies of the report may be obtained from the Director (OWA), U.S. Fish and Wildlife Service, Department of the Interior, Washington, D.C. 20240.

The Proceedings of The MITIGATION SYMPOSIUM/A National Workshop on Mitigating Losses of Fish and Wildlife Habitats are available free from Publications Distribution, U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station, 240 West Prospect St., Fort Collins, CO 80526. ■

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Coming Events

International Symposium on Inland Waters and Lake Restoration, Portland, Maine, September 8-12.

National Symposium on Freshwater Inflow to Estuaries, San Antonio, Texas, September 9-11.

Annual Meeting, American Fisheries Society, Louisville, Kentucky, September 21-24.

70th Annual Meeting, International Association of Fish and Wildlife Agencies, Louisville, Kentucky, September 24-26.

Marine Technology 80, Shoreham Hotel, Washington, D.C., October 6-8.

16th American Water Resources Conference, Minneapolis, Minnesota, October 12-16.

13th Dredging Seminar, Texas A&M University, College Station, Texas, November 6-7.

Coastal Zone 80, Diplomat Resort Hotel, Hollywood, Florida, November 17-20. ■

Changes of Command

Brigadier General Hugh G. Robinson succeeded **Brigadier General James C. Donovan** on August 1 as the U.S. Army Corps of Engineers' Southwestern division engineer. Robinson was deputy director of Civil Works, Office of the Chief of Engineers, in Washington, D.C. Donovan, who is retiring from the military after 30 years of active duty, had been Southwestern division engineer since July 1977.

Colonel Paul Bazilwich, Jr., has been named district engineer for the Corps of Engineers' San Francisco district. Bazilwich became San Francisco district engineer on June 16, succeeding **Colonel John M. Adsit** whose next assignment will be announced later. Bazilwich was formerly deputy division engineer of the North Atlantic Division office in New York, NY.

Colonel Charles E. Eastburn has been named district engineer for the Corps' Louisville district. Eastburn will become Louisville district engineer on August 22, succeeding **Colonal Thomas P. Nack** whose next assignment will be announced later. Eastburn was previously assigned to Fort Benning, GA, as director of Facilities Engineering.

Colonel Robert K. Hughes has been named as district engineer for the Wilmington district, effective July 1, succeeding **Colonel Adolph A. Hight.** He was previously assigned to the Office, Chief of Engineers, in Washington, D.C., as assistant director of Military Programs.

Colonel Walter M. Smith, Jr., became district engineer for the New York district on June 27, succeeding **Colonel Clark H. Benn.** Smith was previously serving as chief of the Management Division, Office of the Deputy Chief of Staff, Engineer at the Headquarters of the U.S. Army, Europe.

Colonel Lee W. Tucker became Nashville district engineer on June 23, succeeding **Colonel Robert K. Tener.** Tucker was previously a student at the Army War College at Carlisle Barracks, PA.

Lieutenant Colonel Bernard E. Stalmann was named district engineer for the Charleston district on July 18, succeeding **Colonel William W. Brown.** He was previously remote sites resident engineer for the Corps' Alaska district.

Lloyd E. Anderson, executive director of the Port of Portland (Ore.) Commission, has been elected to a one-year term as chairman of the National Waterways Conference, Inc. ■

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Summer finds the sailing season in full tack of Hilton Head, SC. See "Boating the Atlantic Intracoastal Waterway" on page 24. (Photo by Prof. R. N. Saveland)